U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

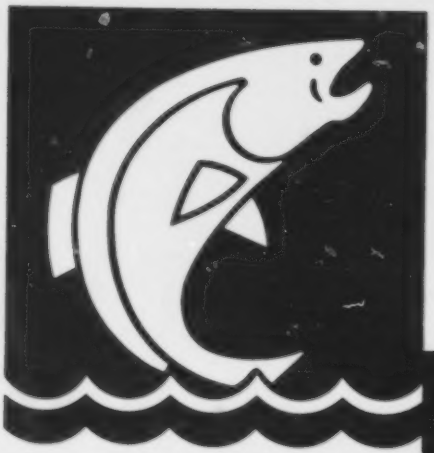
PB-286 849

# Probability-of-Use Criteria for the Family Salmonidae

(U.S.) Fish and Wildlife Service, Fort Collins, CO

Jan 78

PB 286849

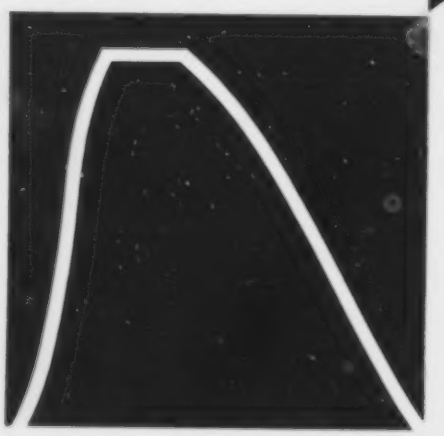


# Probability Of Use Criteria For The Family Salmonidae.

COOPERATIVE INSTREAM FLOW SERVICE GROUP

INSTREAM FLOW INFORMATION PAPER: NO. 4

FWS/OBS-78/07
JANUARY 1978



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Environmental Protection Agency
Heritage Conservation and Recreation Service
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16. Abstracts

The report gives the probability-of-use criteria for the hydraulic parameters of depth, velocity, substrate and temperature for the family Salmonidae. It is intended as a companion document to Instream Flow Information Paper No. 3, "Development and Evaluation of Weighted Criteria, Probability-of-Use Curves for Instream Flow Assessments: Fisheries," which describes the techniques used to construct and criteria used to evaluate each set.

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January 1978

# PROBABILITY-OF-USE CRITERIA FOR THE FAMILY SALMONIDAE

Instream Flow Information Paper No. 4

by

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Cooperative Instream Flow Service Group
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Fort Collins, Colorado 80521

This study was conducted
as part of the Federal
Interagency Energy/Environment
Research and Development Program
Office of Research and Development
U.S. Environmental Protection Agency

Cooperative Instream Flow Service Group
Western Energy and Land Use Team
Office of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior

[1] Hydrologist, Geology Department, University of Montana, Missoula, MT on IPA Assignment from December 1976 - December 1977, to Cooperative Instream Flow Service Group.

-- ADDENDUM --

It has come to our attention that there may be some undetected data bias in the curves for steelhead. The information we have received to date, suggests that the depth curves for steelhead fry and juveniles do not tail off at depths greater than 1.5 feet (juvenile curve) or 0.5 ft (fry curve) Additionally, the depth curve for spawning steelhead is probably appropriate for small streams only. For larger rivers, it is likely that this curve as well, does not tail off at depths greater than the indicated optimum depth. We hope to have the answers to some of these discrepancies by the time the next update of these curves is published.

# PREFACE

This document gives probability-of-use criteria for the hydraulic parameters of depth, velocity, substrate, and temperature, for the family Salmonidae. It is intended as a companion document to Instream Flow Information Paper No. 3, Development and Evaluation of Weighted Criteria, Probability-of-Use Curves for Instream Flow Assessments: Fisheries, which describes the techniques used to construct and criteria used to evaluate each set. The user is urged to keep both volumes together for cross-reference.

Except for egg incubation, a curve set for each life stage consists of four curves; one each for velocity, depth, substrate, and temperature. The criteria selected for egg incubation is a function of the channel slope and sediment concentration. Incubation is usually represented by six curve sets, with different combinations of slope and sediment concentration. The user should select the curve set which most closely resembles the conditions at each study area.

A curve maintenance program has been developed by the Instream Flow Group to store a digitized file of these curves on magnetic tape. This program will be utilized by IFG to store new curves and update old ones. Updated versions of curves and curves for species not included in this

publication will be released by IFG periodically as new data becomes available. Any comments or questions involving these curves, or any additional data on the family Salmonidae, may be directed to:

Cooperative Instream Flow Service Group
U.S. Fish and Wildlife Service
Room 206, Federal Building
Fort Collins, Colorado 80521

We extend our gratitude to those individuals who have submitted unpublished data on various species of fish. Without their cooperation the development of probability criteria would have been virtually impossible. Contributing individuals and organizations are listed below:

Mr. Liter Spence
Montana Department of Fish and Game

Mr. Tim Cochnauer
Idaho Department of Fish and Game

Messrs. Jeff Gosse, R. S. Wydoski, and W. T. Helm
Utah Cooperative Fishery Research Unit
Utah State University

Mr. D. L. Hanson
Washington Department of Game

Oregon State Game Commission
Oregon State Fish Commission

The following list of substrate codes will be useful in the reading and interpretation of the probability curves for substrate.

| SUBSTRATE | CODE NUMBER |
|---|---|
| Plant detritus/ organic material | 1 |
| Mud/Soft Clay | 2 |
| Silt | 3 |
| Sand | 4 |
| Gravel | 5 |
| Cobble/Rubble | 6 |
| Boulder | 7 |
| Bedrock | 8 |

NOTE: Gradations between code numbers refer to a rough proportion between one substrate type and another. For example, a 5.5 substrate code would indicate a gravel/cobble mixture with approximately equal portions of each particle size. A code of 4.8 would indicate a mix of approximately 80% gravel and 20% sand, whereas a code of 5.2 would mean 80% gravel and 20% cobble.

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# COHO SALMON

## *Oncorhynchus kisutch*

| Catalog No. | 10010 Spawning | | | | Adult | | | | Juvenile | | | | 10000 Fry | | | | 10021-10026 Egg Incubation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES: Coho | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature |
| IFG EVALUATION | G | G | F | R | | | | | | | | | E | E | E | G | F | F | F | R |
| REFERENCE / ANALYSIS | 1 FA | 1 FA | 1 FA | 1 RD | | | | | | | | | 15 FA | 15 FA | 15 FA | 5 RD | 9,10 IN | 9,10 IN | 10 IN | 5 PO |
| | | | 7 RD | 31 RD | | | | | | | | | | | | 15 FA | 24 29 IN | 24 29 IN | 36 IN | 10 RD |
| | | | | | | | | | | | | | | | | | 38 IN | 38 IN | 38 IN | 31 PO |
| | | | | | | | | | | | | | | | | | 36 IN | 36 IN | | |
| COMMENTS | | | | | | | | | | | | | | | | | | | | |

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

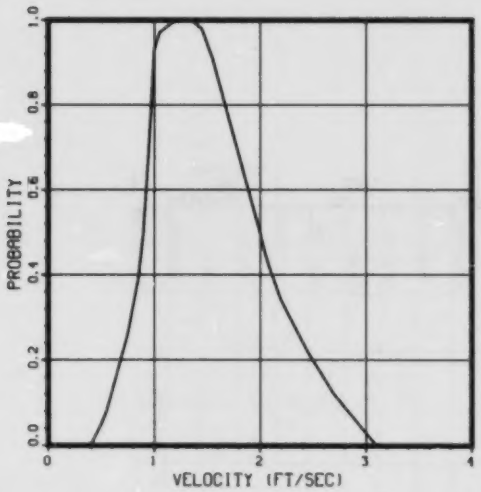
Analysis: FA - frequency analysis
RD - range and optimum
PO - Parameter overlap
IN - indirect analysis

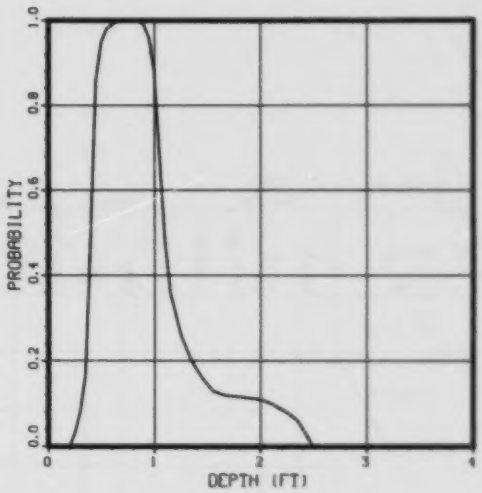
Reference: Refer to listed number in bibliography.

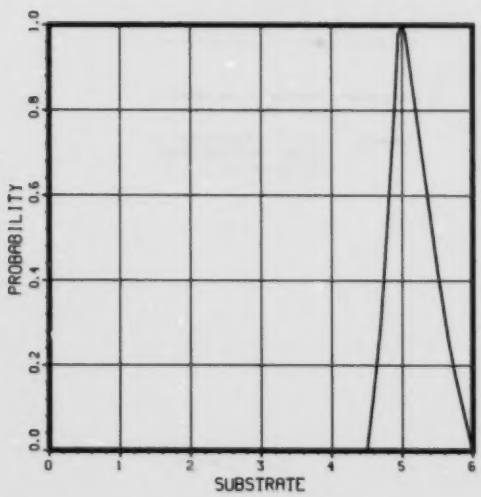
Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

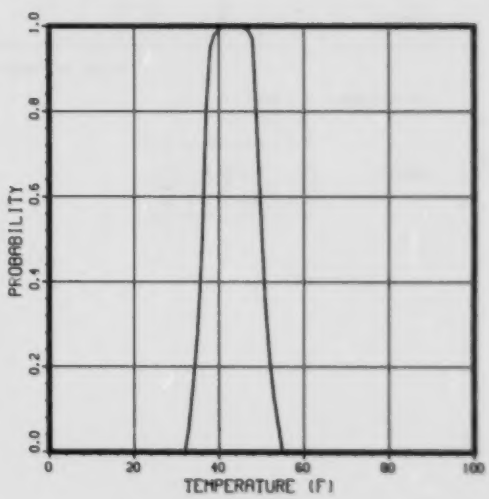
COHO SALMON

10010 SPAWNING 78/01/24.



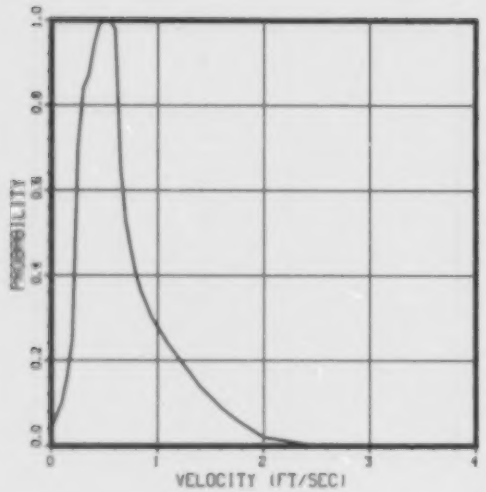



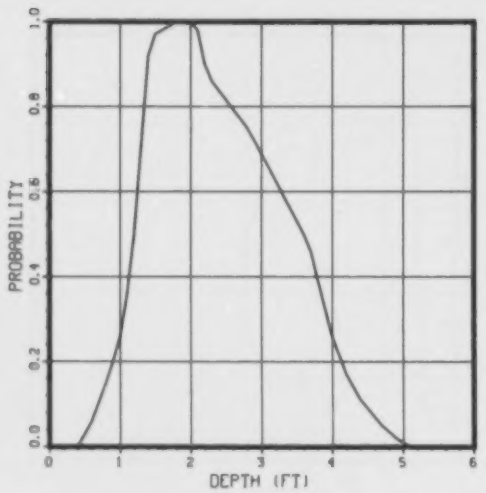



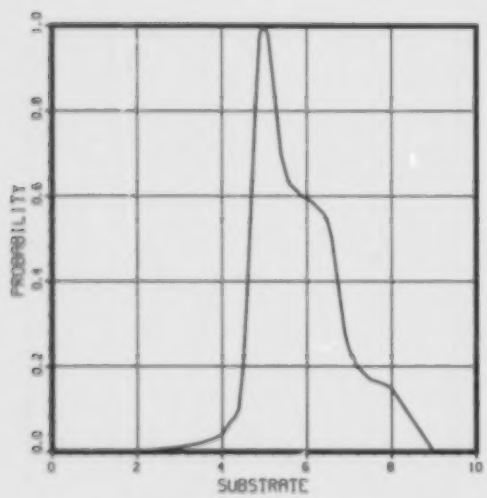



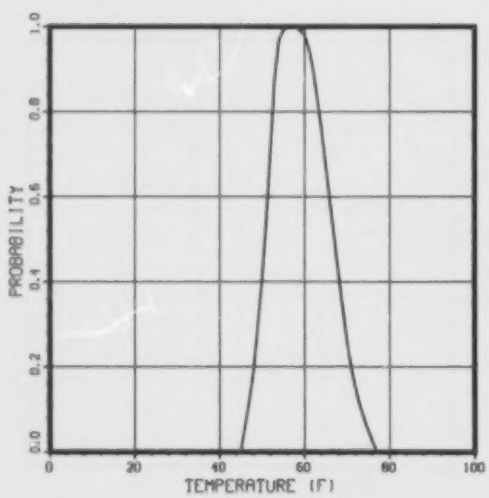
COHO SALMON

10000 FRY 78/01/24.



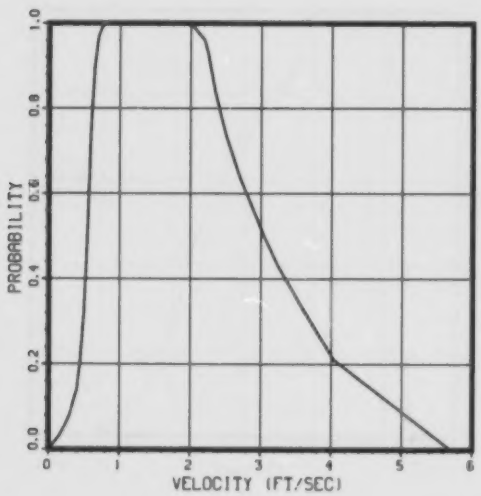



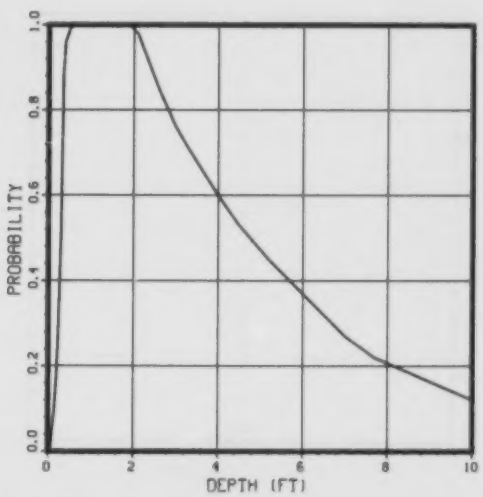



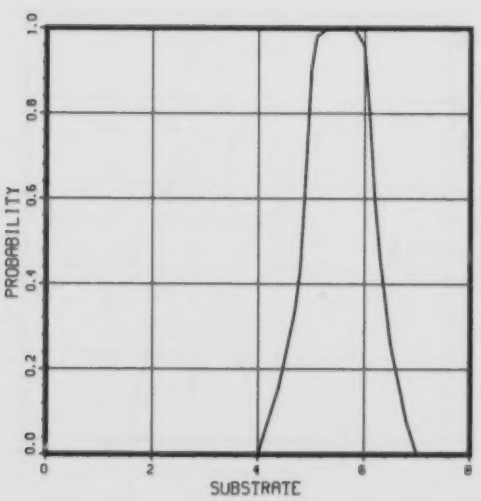



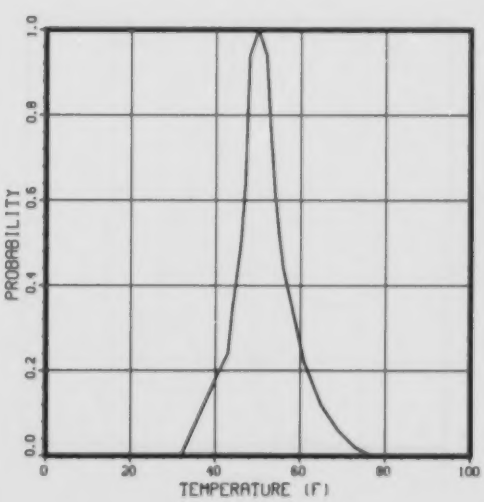
COHO SALMON (CLEAR WATER, S=.001)

10021 INCUBATION 78/01/24.



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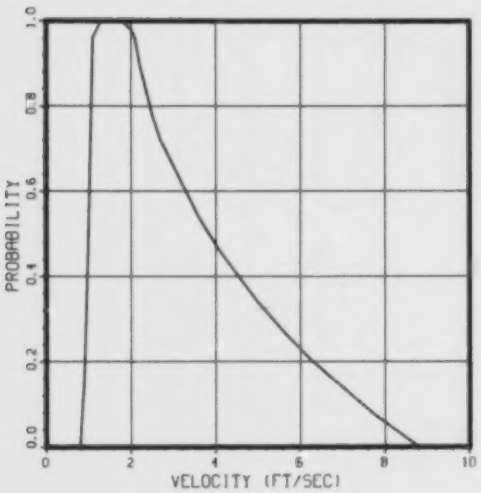


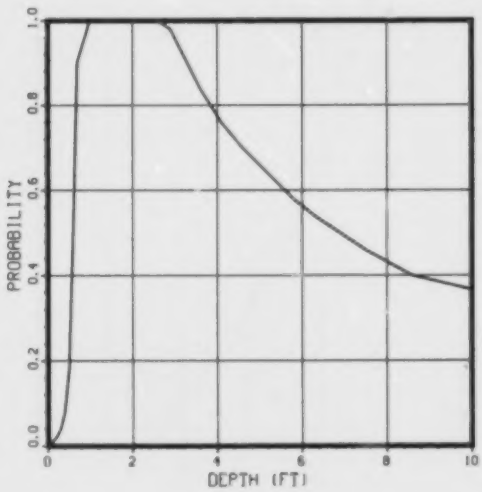


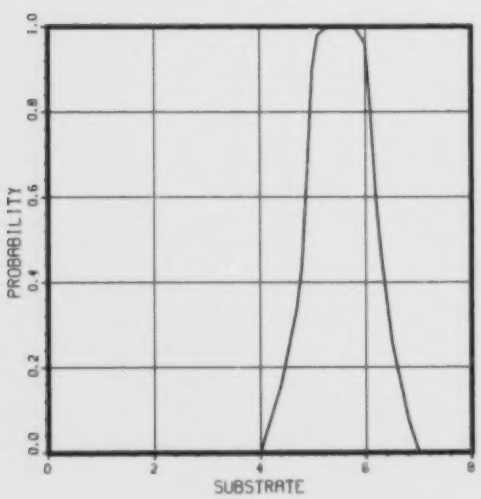


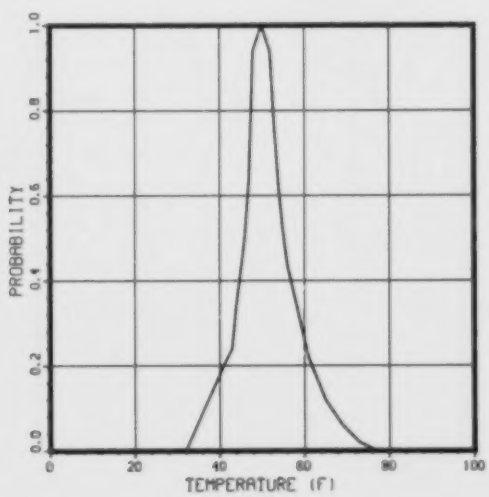

COHO SALMON (CLEAR WATER, S=.0025)

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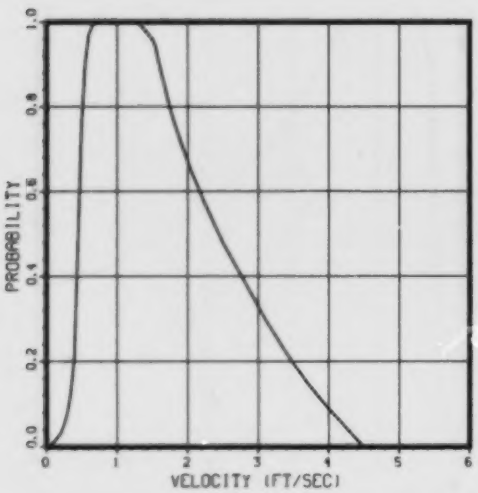


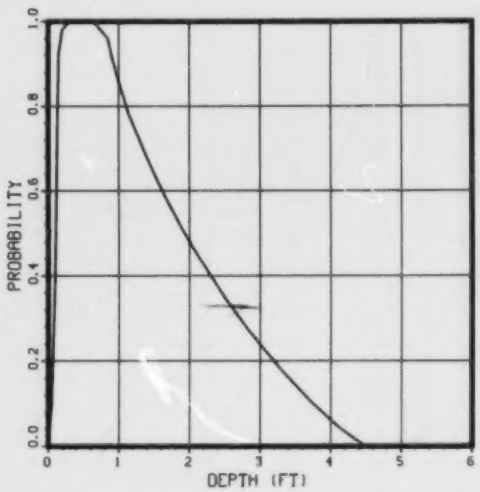


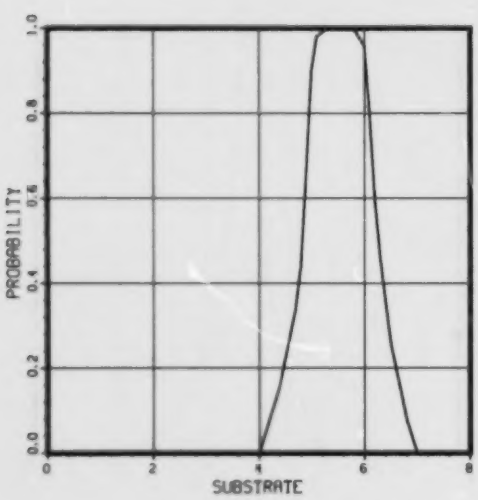


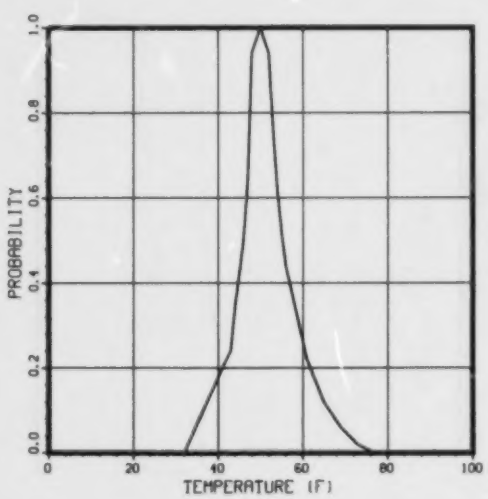

COHO SALMON (TURBID WATER, S=.0025)

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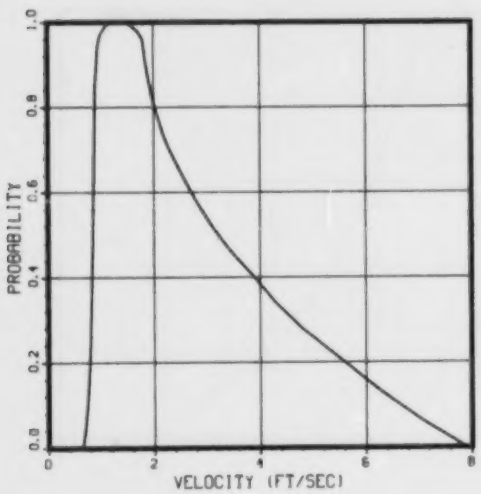


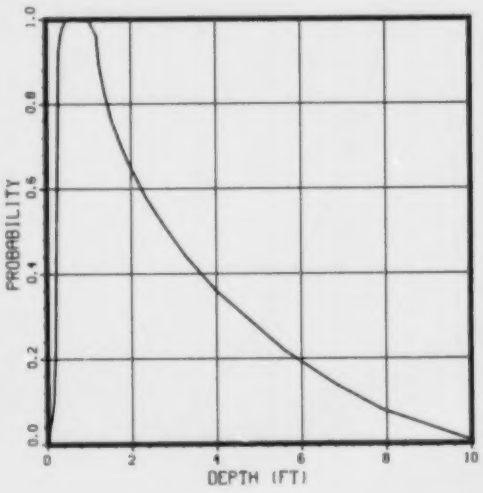


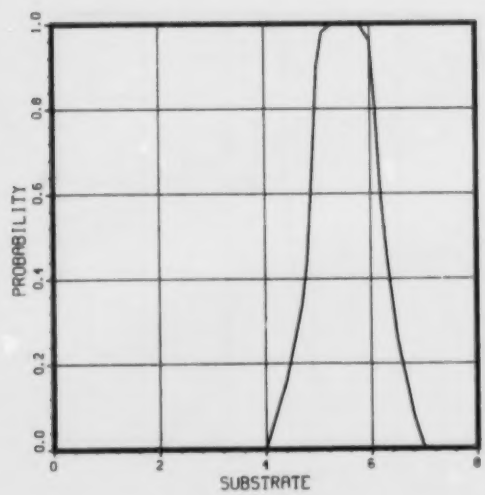


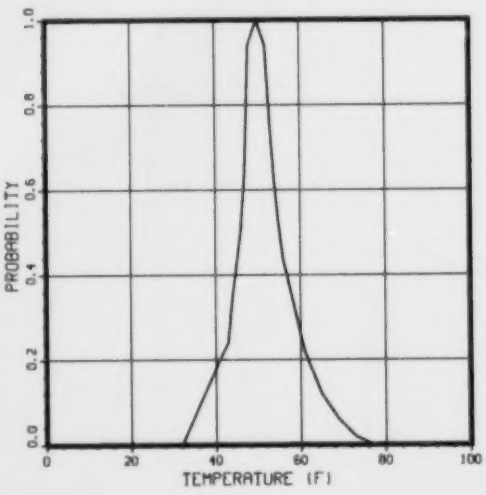

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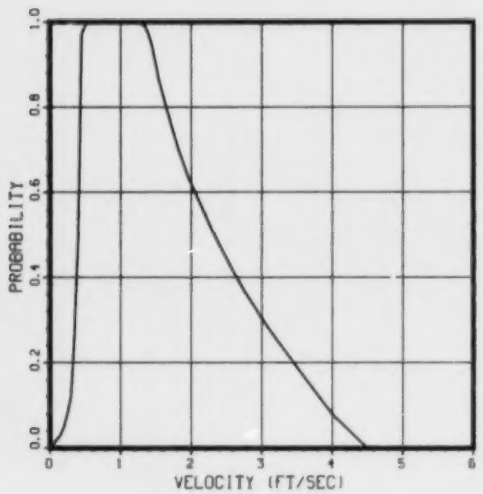


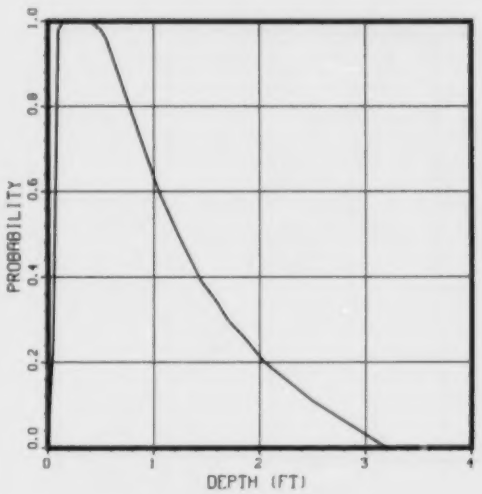


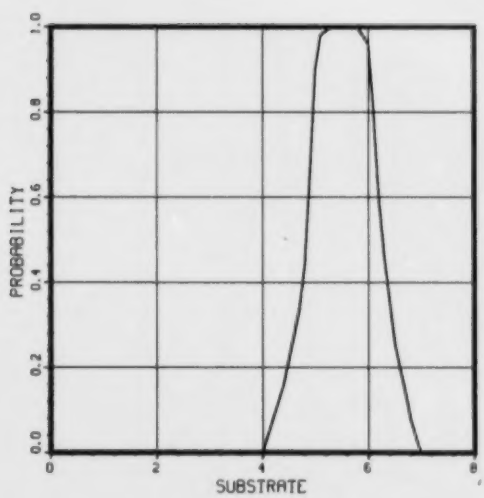


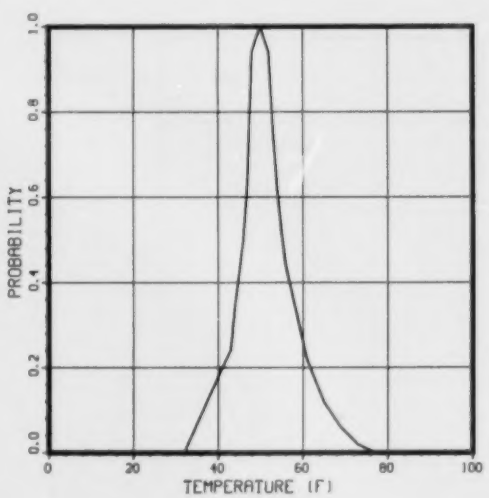

COHO SALMON (TURBID WATER, S=.004)

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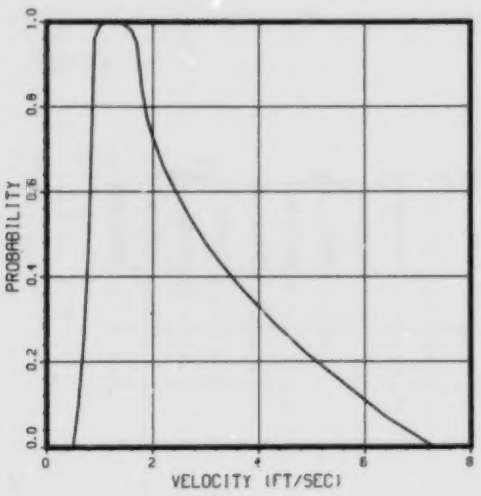
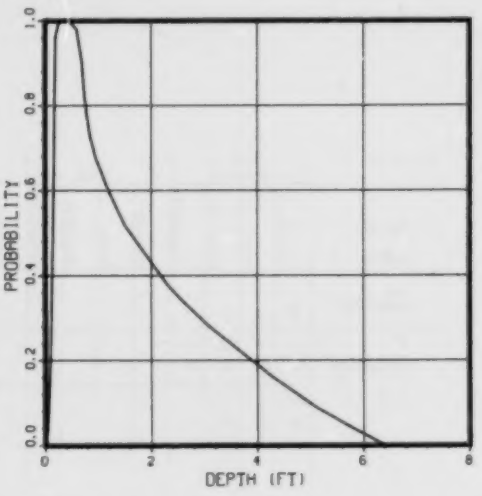
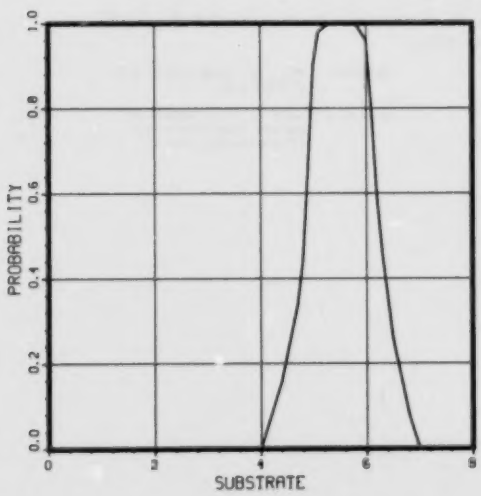
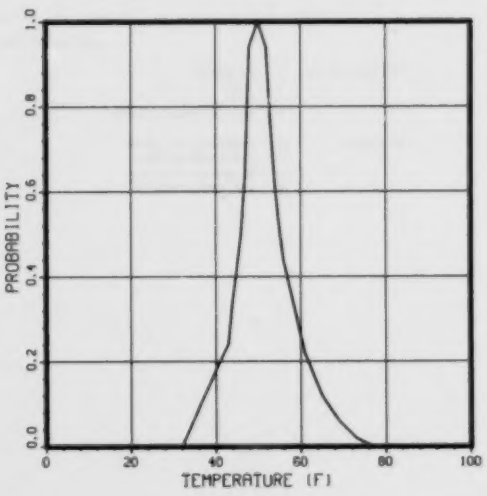


# SOCKEYE SALMON

## Oncorhynchus nerka

| Catalog No. | 10310 Spawning | | | | Adult | | | | Juvenile | | | | Fry | | | | Egg Incubation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES: Sockeye | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature |
| IFG EVALUATION | F | F | F | R | | | | | | | | | | | | | | | | |
| REFERENCE | 7 RO | 7 RO | 21 RO | 31 RO | | | | | | | | | | | | | | | | |
| | 21 RO | 21 RO | 7 RO | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| ANALYSIS | | | | | | | | | | | | | | | | | | | | |
| COMMENTS | | | | | | | | | | | | | | | | | | | | |

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

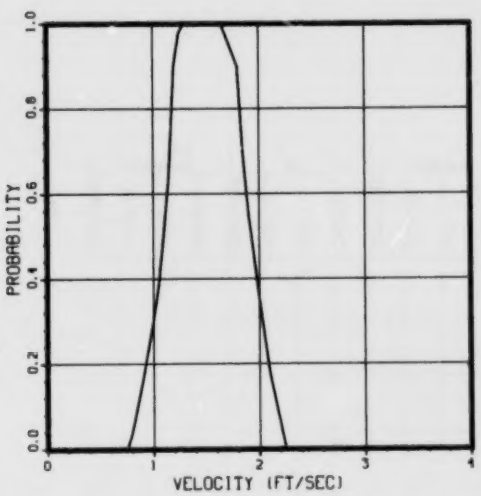
Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

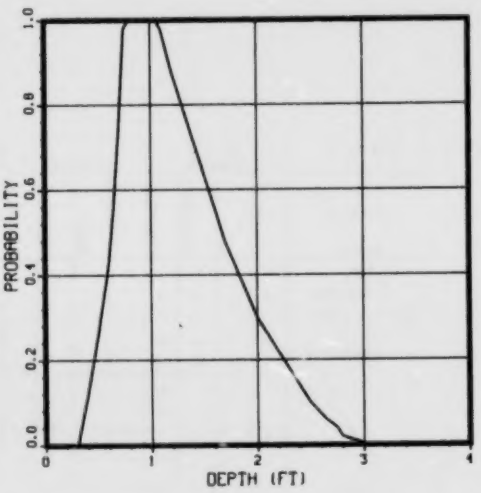
Reference: Refer to listed number in bibliography.

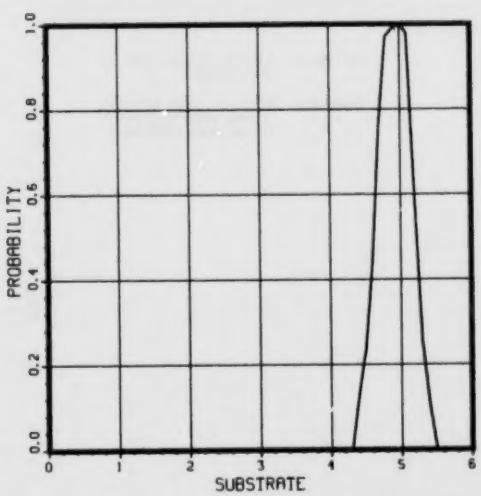
Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

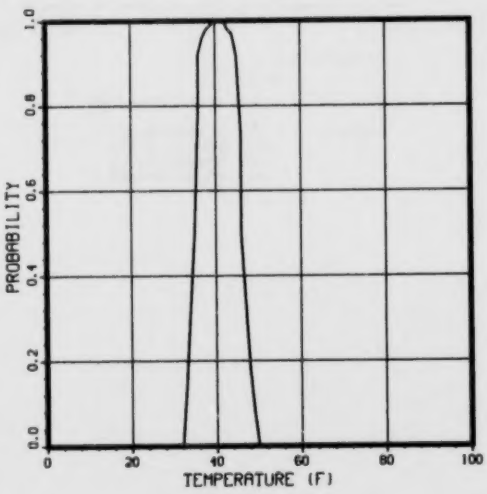
SOCKEYE SALMON

10310 SPAWNING 78/01/24.



# KOKANEE

## Oncorhynchus nerka

| Catalog No. | 10210 Spawning | | | | Adult | | | | Juvenile | | | | Fry | | | | Egg Incubation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES: Kokanee | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature |
| IFG EVALUATION | G | G | F | F | | | | | | | | | | | | | | | | |
| REFERENCE / ANALYSIS | 22 FA | 22 FA | 21 RO | 22 PO | | | | | | | | | | | | | | | | |
| | | | | 31 PO | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| COMMENTS | | | | | | | | | | | | | | | | | | | | |

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

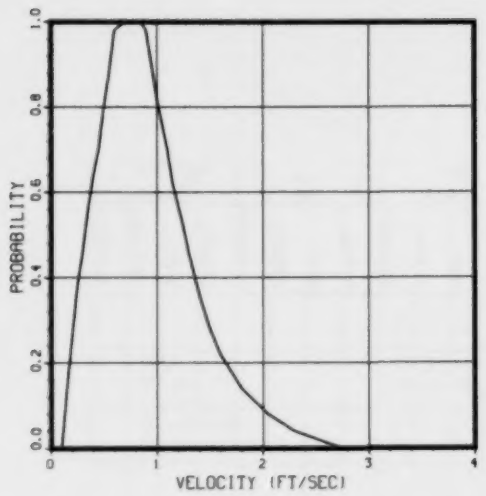
Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

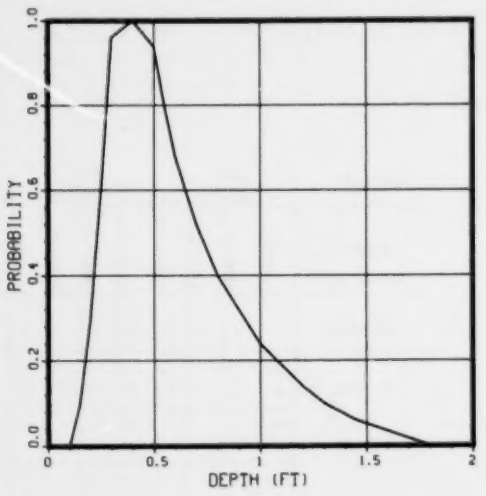
Reference: Refer to listed number in bibliography.

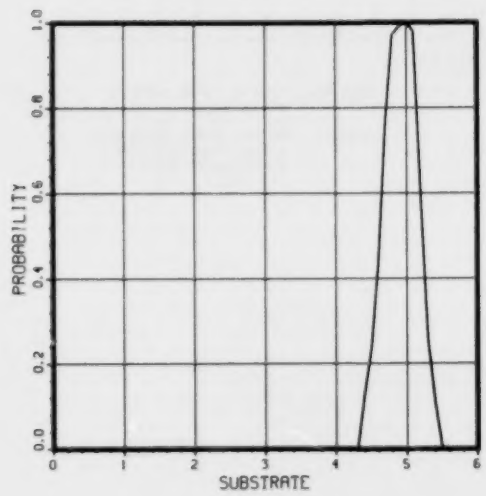
Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

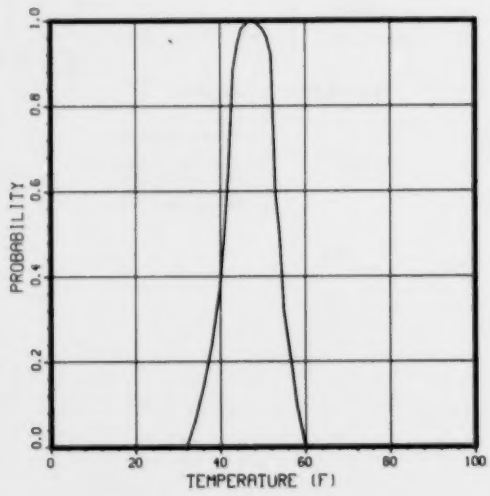
KOKANEE SALMON

10210 SPAWNING 78/01/24.



# CHINOOK SALMON

## Oncorhynchus tshawytscha

| Catalog No. | 10111 Spring Spawning | | | | 10112 Fall Spawning Adult | | | | 10101 Juvenile | | | | Fry | | | | 10121-10126 Egg Incubation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES: Chinook Salmon | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature |
| IFG EVALUATION | E | E | G | F | G | G | F | F | G | G | E | G | | | | | F | F | F | |
| REFERENCE / ANALYSIS | 1 FA | 1 FA | 1 FA | 1 PO | 1 FA | 1 FA | 1 FA | 1 RO | 14 FA | 14 FA | 15 FA | 5 FA | | | | | 1 IN | 1 IN | 36 IN | |
| | 32 RO | 32 RO | | | 23 FA | 23 FA | | | 15 FA | 15 FA | | 15 FA | | | | | 9,24 IN | 9,24 IN | 38 IN | |
| | | | | | 30 FA | 30 FA | | | | | | | | | | | 36 IN | 36 IN | | |
| | | | | | 32 RO | 32 RO | | | | | | | | | | | 38 IN | 38 IN | | |
| COMMENTS | | | | | | | | | | | | | | | | | | | | |

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

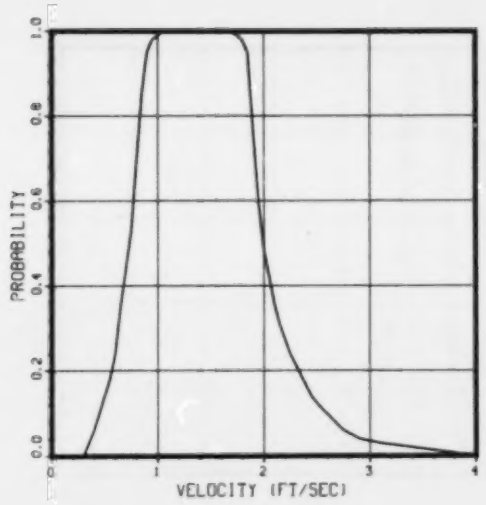
Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

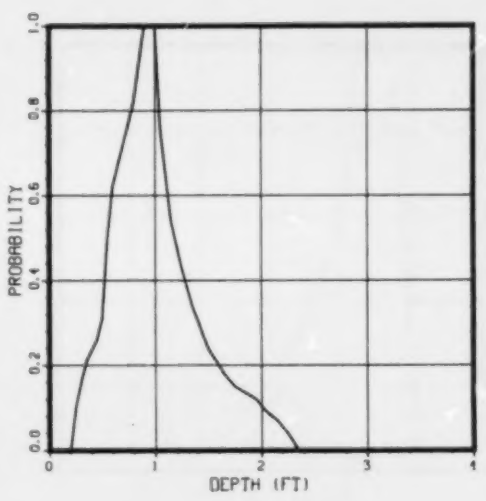
Reference: Refer to listed number in bibliography.

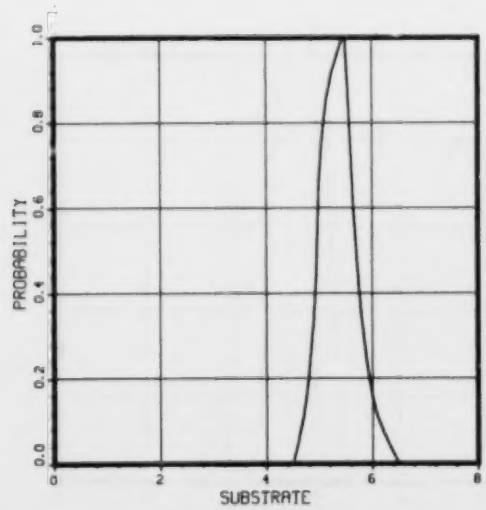
Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

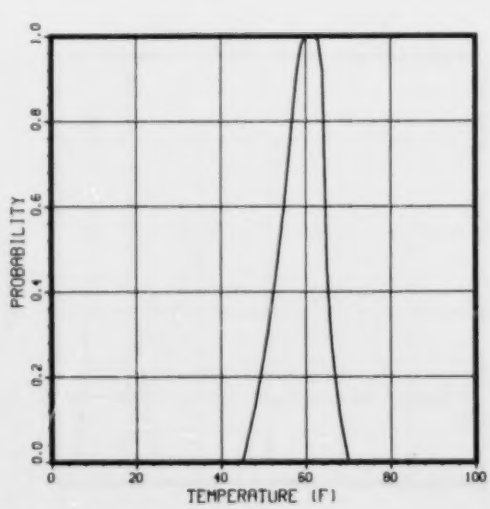
SPRING CHINOOK

10111 SPAWNING 78/01/24.



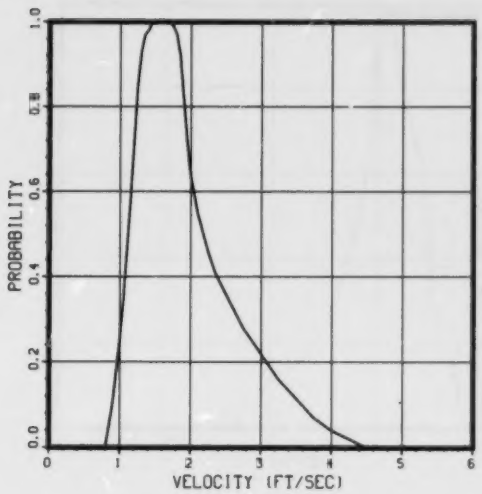



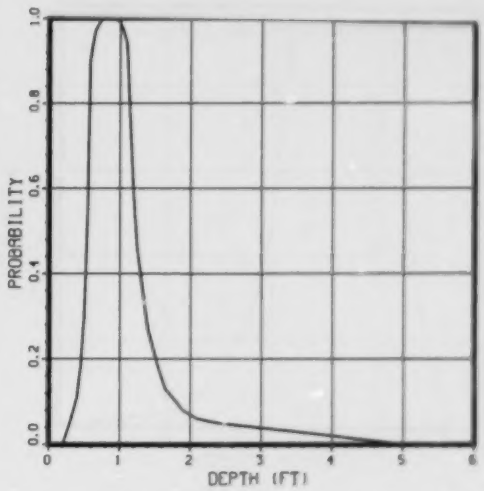



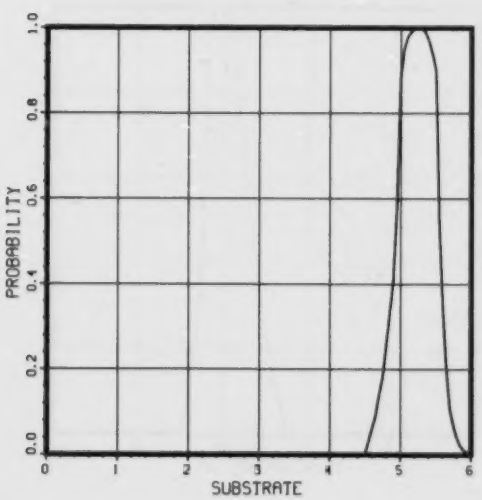



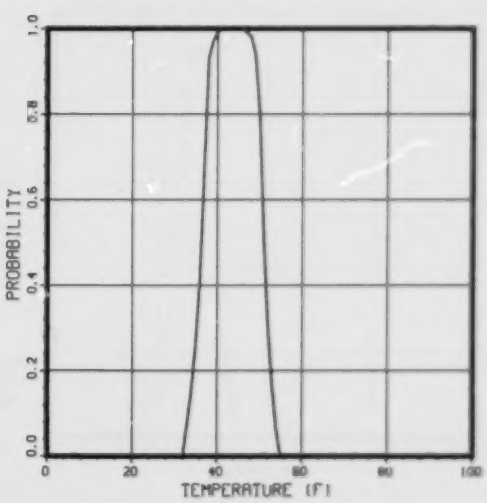
FALL CHINOOK

10112 SPAWNING 78/01/24.



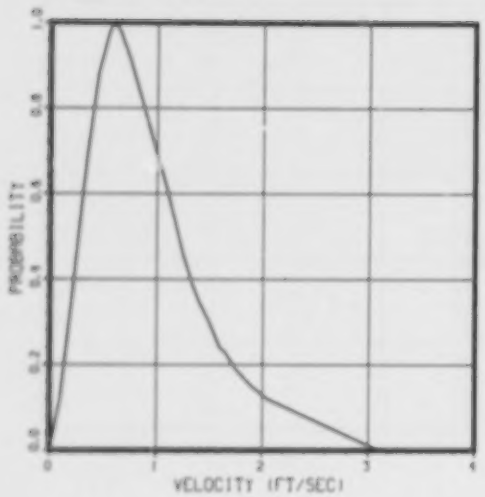



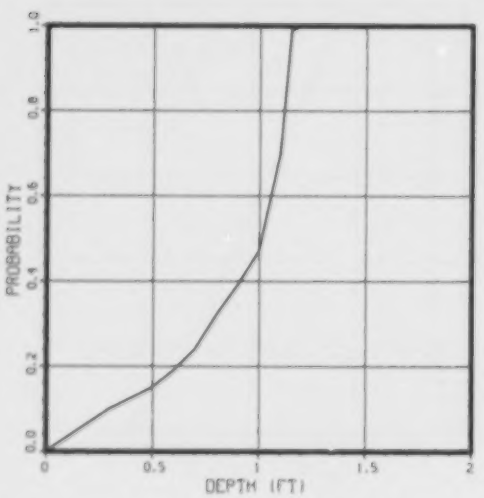



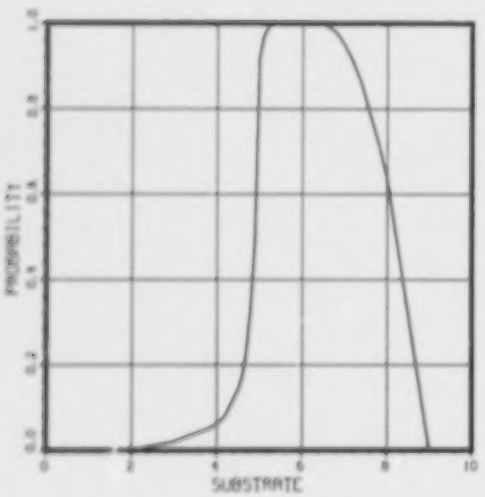



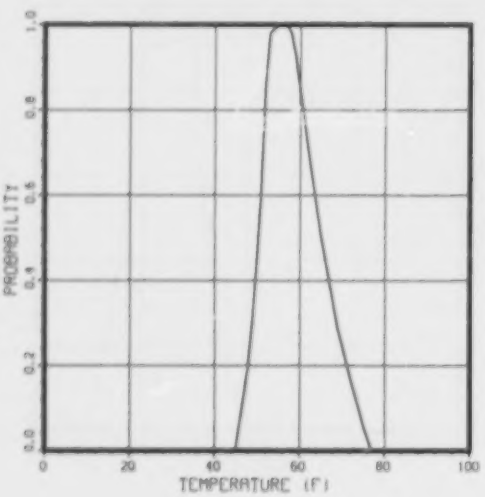
CHINOOK SALMON

10101 JUVENILE 78/01/24.



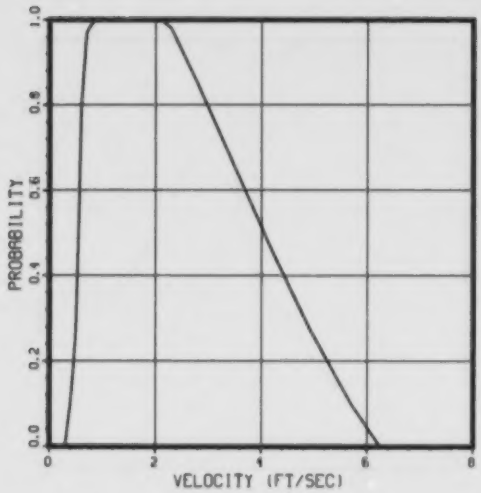



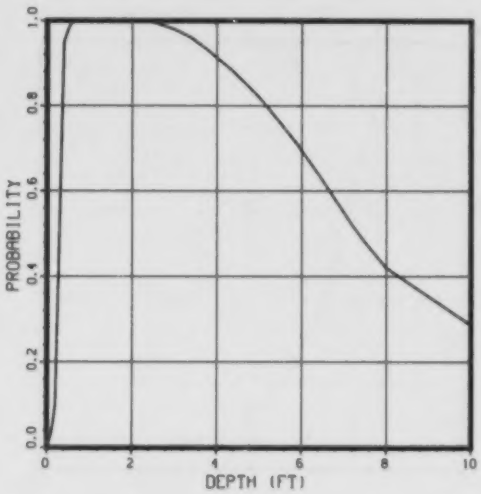



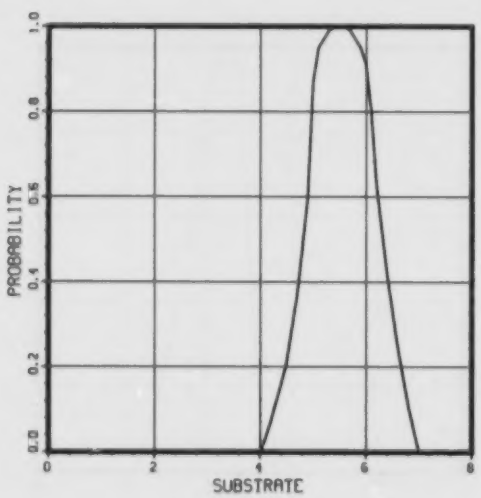



CHINOOK SALMON (CLEAR WATER, S=.001)

10121 INCUBATION 78/01/24.

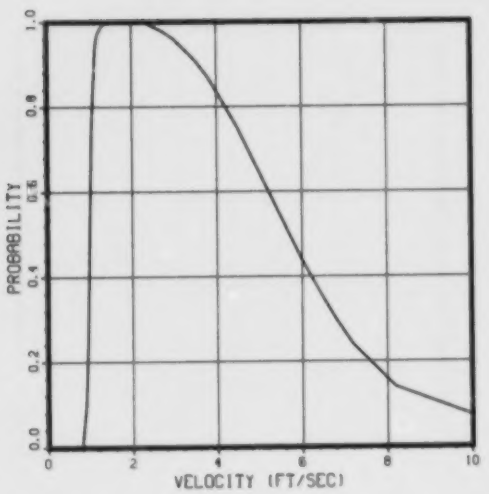


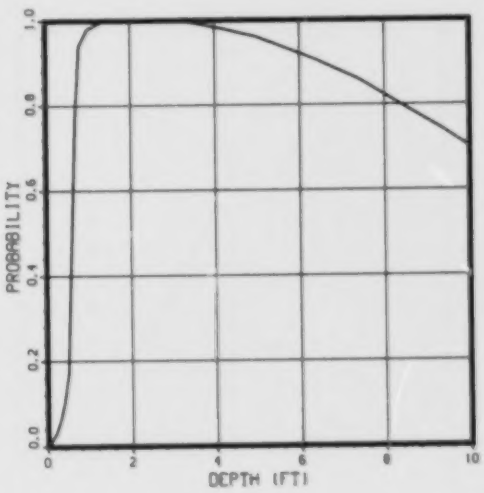



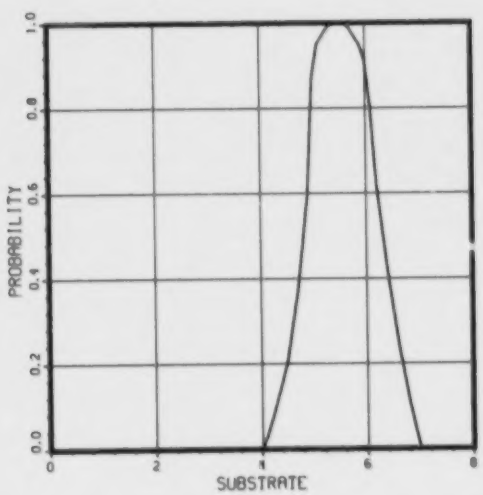



CHINOOK SALMON (TURBID WATER,S=.001)

10122 INCUBATION 78/01/24.

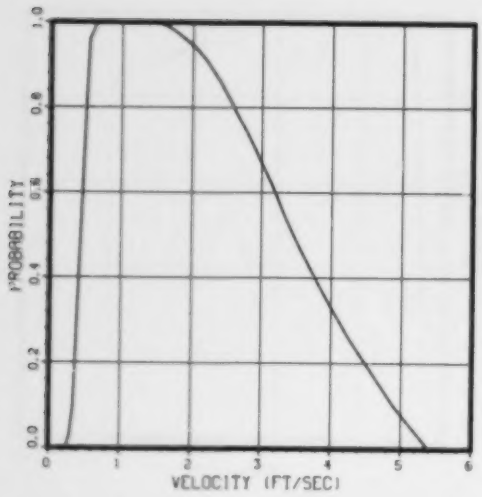


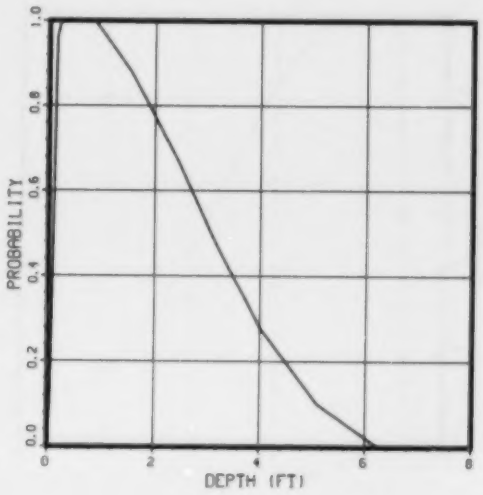



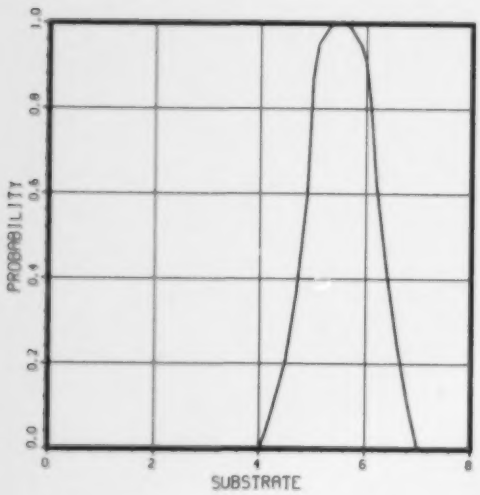



CHINOOK SALMON (CLEAR WATER, S-.0025)

10123 INCUBATION 78/01/24.

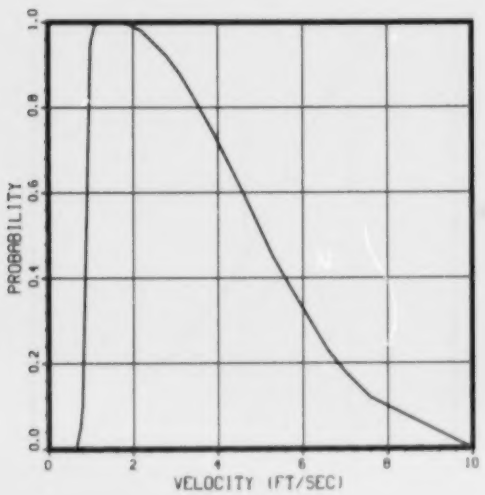


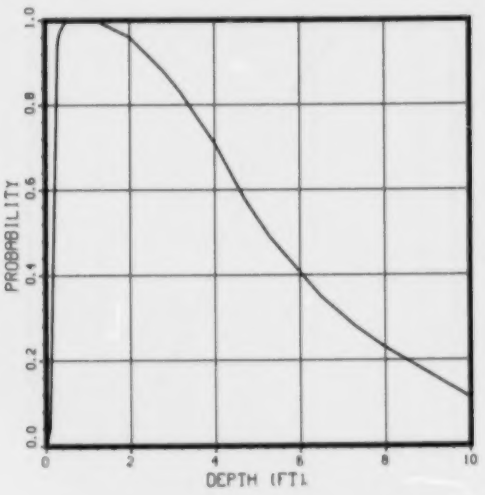



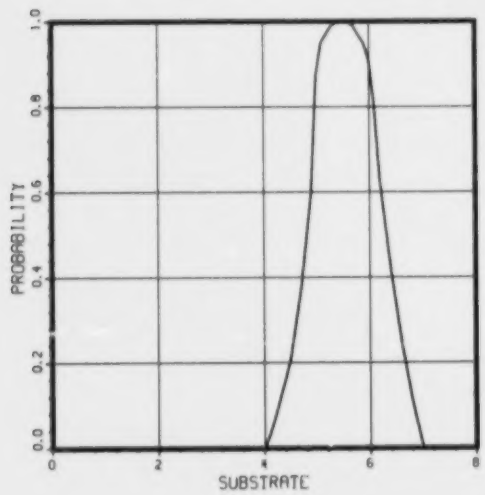



CHINOOK SALMON (TURBID WATER, S=.0025)

10124 INCUBATION 78/01/24.

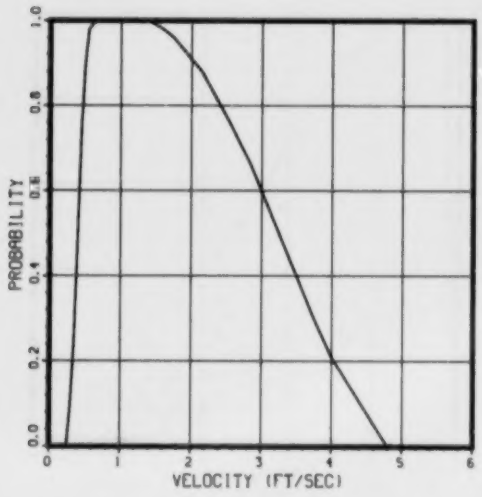


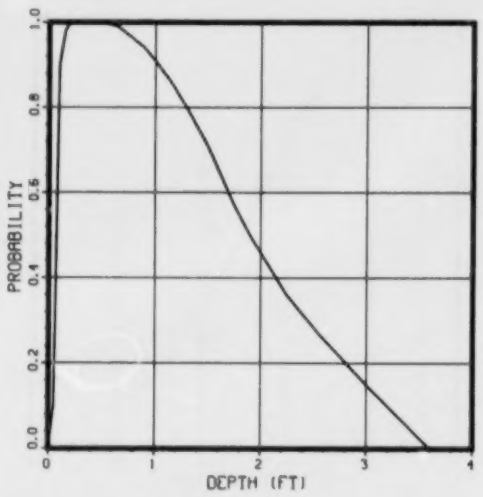



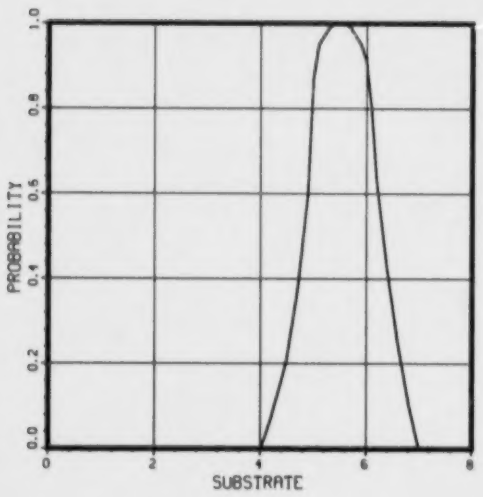



CHINOOK SALMON (CLEAR WATER, S=.004)

10125 INCUBATION 78/01/24.

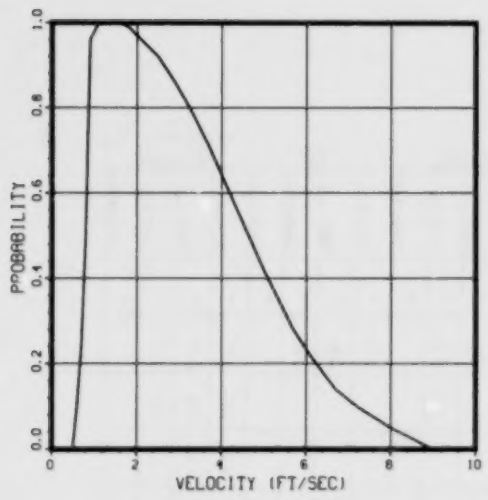


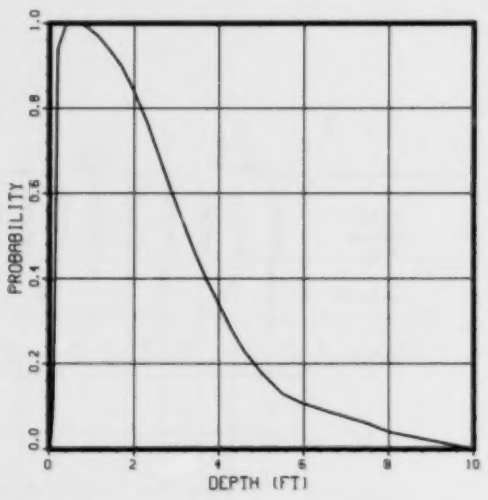



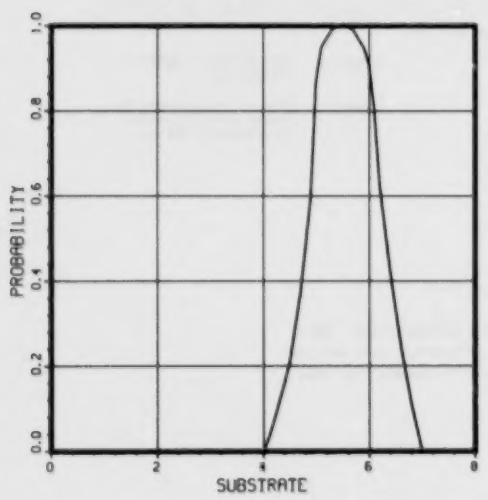



CHINOOK SALMON (TURBID WATER, S=.004)

10126 INCUBATION 78/01/24.



# CUTTHROAT TROUT

## Salmo clarki

| | 11210 Spawning | | | | 11202 Adult | | | | 11201 Juvenile | | | | 11200 Fry | | | | 11221-11226 Egg Incubation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES: Cutthroat trout | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature |
| IFG EVALUATION | F | F | F | F | F | F | F | R | G | G | G | R | F | F | G | R | F | F | F | R |
| REFERENCE / ANALYSIS | 22 FA | 22 FA | | 20 RO | 15 FA | 15 FA | 15 FA | | 15 FA | 15 FA | 15 FA | | 15 FA | 15 FA | 15 FA | | 9 IN | 9 IN | 11 IN | |
| | | | | 31 RO | | | | | | | | | | | | | 25 IN | 25 IN | 36 IN | |
| | | | | | | | | | | | | | | | | | 36 IN | 36 IN | | |
| | | | | | | | | | | | | | | | | | | | | |
| COMMENTS | 1 | 1 | 1 2 | 1 | 1 | 1 | 1 | 1 2 | 1 | 1 | 1 | 1 2 | 1 | 1 | 1 | 1 2 | 1 2 | 1 2 | 1 2 | 1 2 |

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

Reference: Refer to listed number in bibliography.

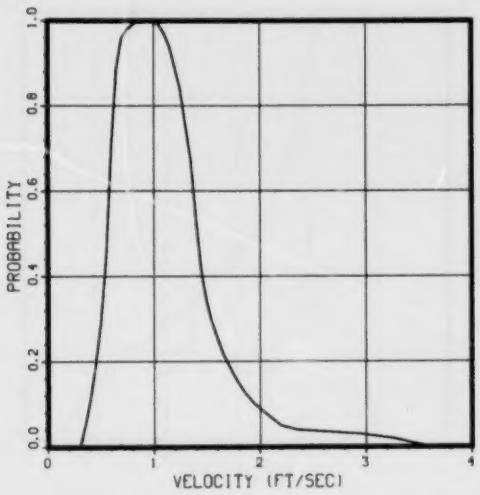
Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

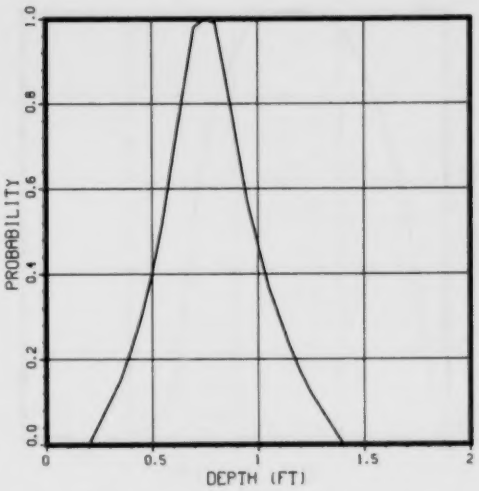
Comments - Cutthroat Trout

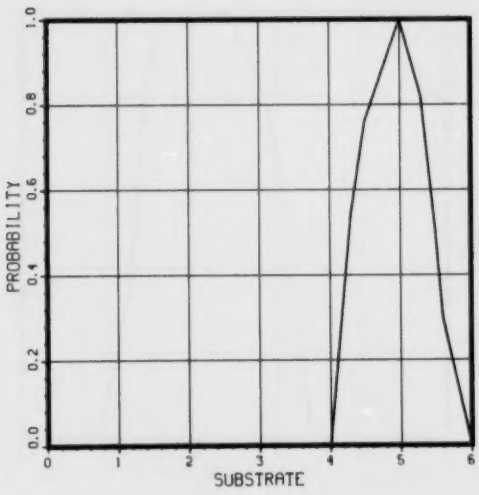
1. These curves represent the composite cutthroat trout. There are so many races and sub-species of cutthroat trout that the criteria for any single race may deviate somewhat from these criteria.
2. Assumed same as rainbow trout.

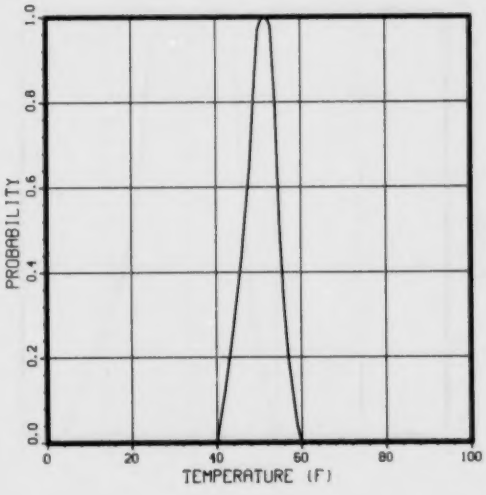
CUTTHROAT TROUT

11210 SPAWNING 78/01/24.



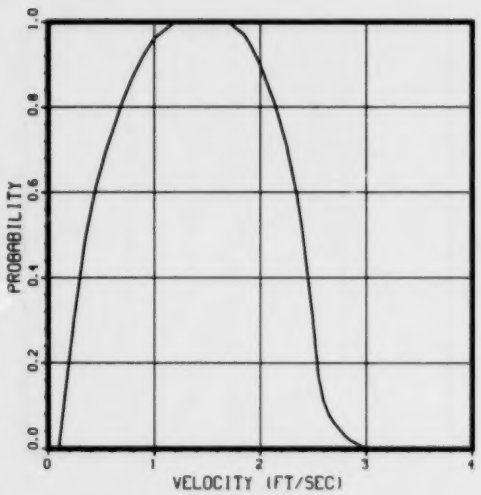



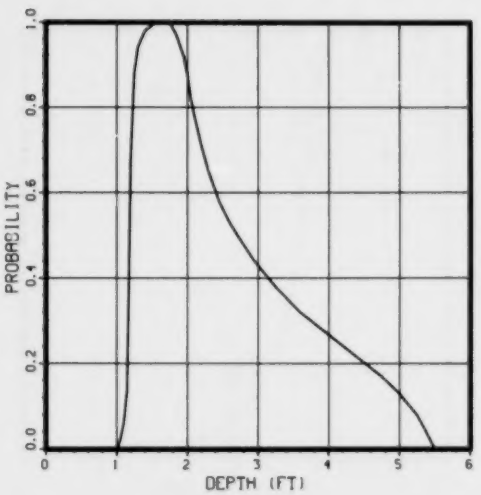



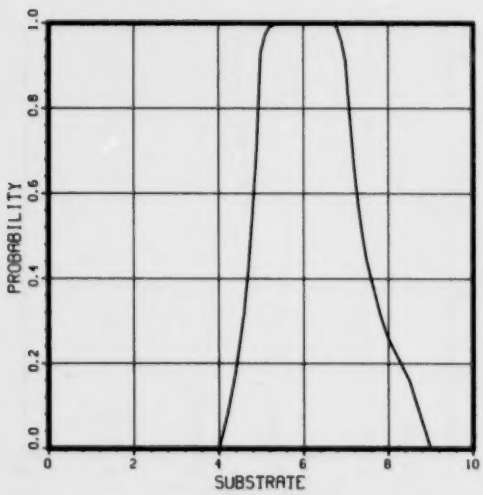



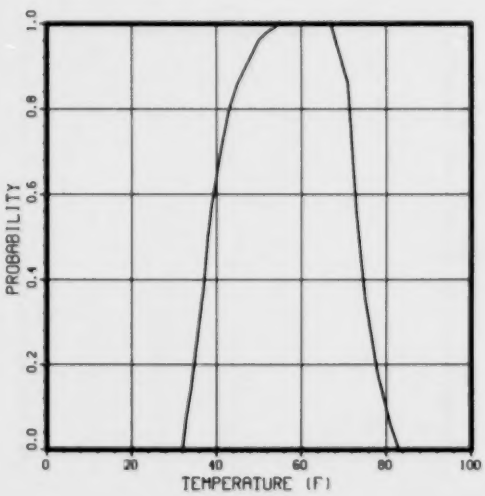
# CUTTHROAT TROUT

11202 ADULTS 78/01/24.



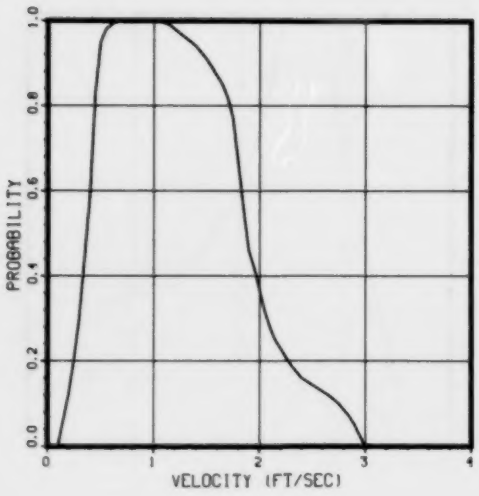



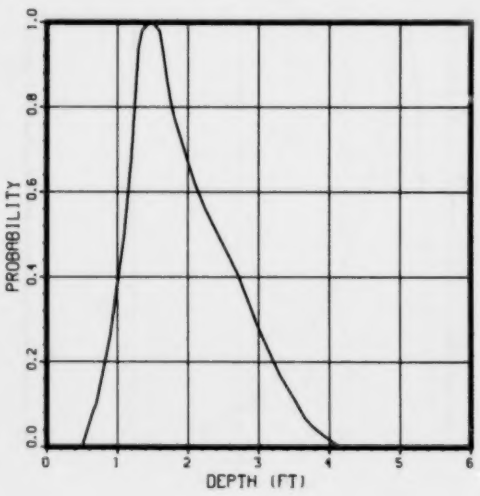



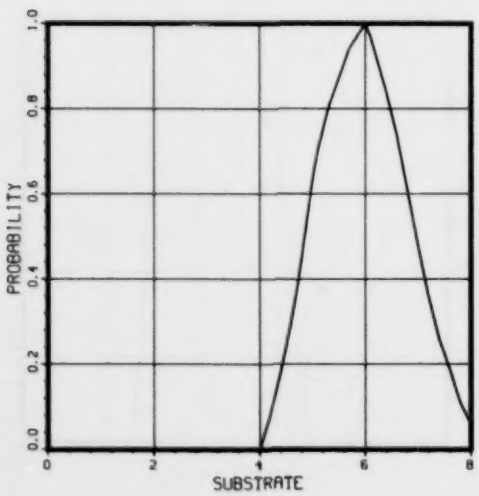



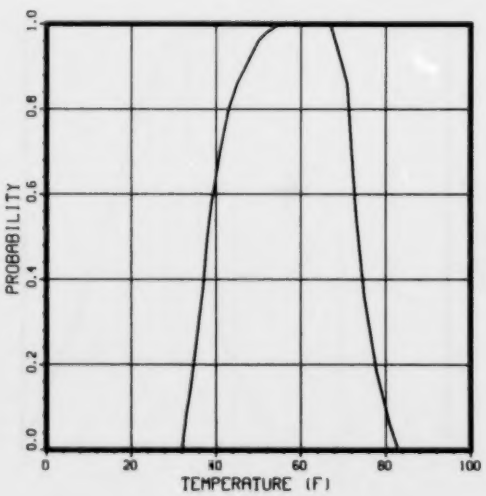
CUTTHROAT TROUT

11201 JUVENILE 78/01/24.



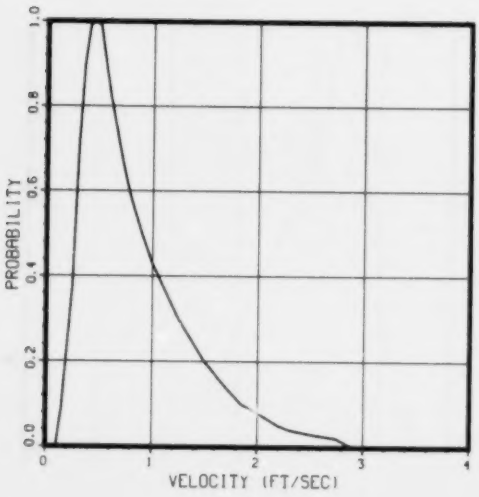



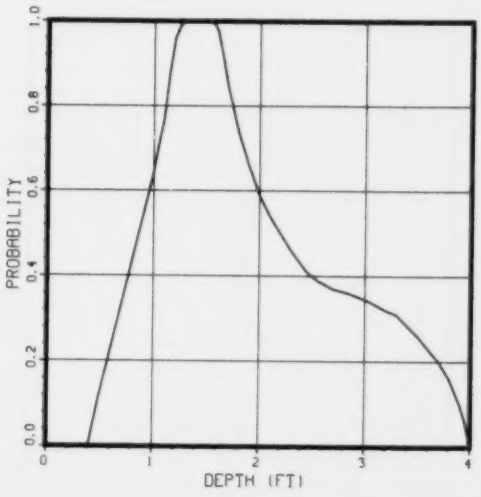



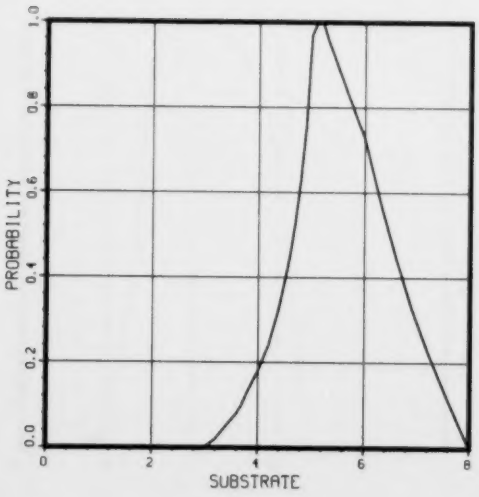



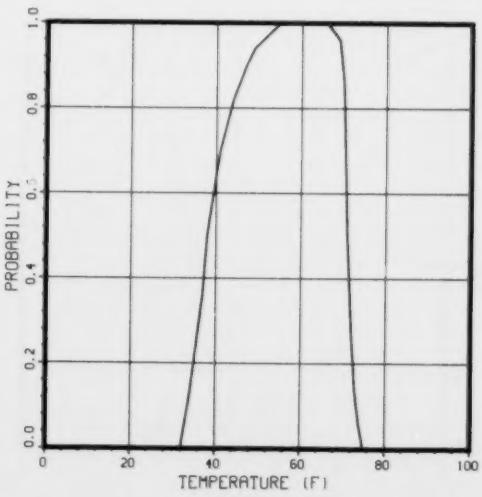
# CUTTHROAT TROUT

11200 FRY 78/01/24.



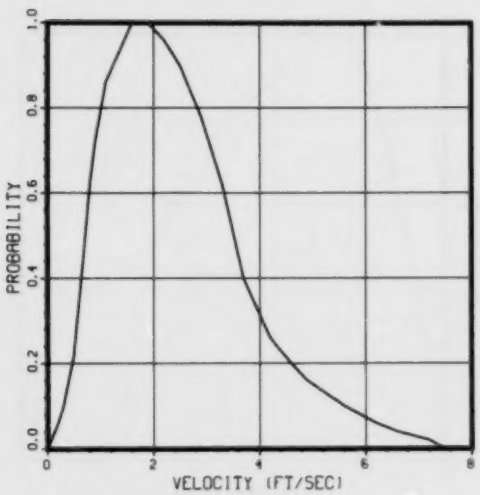



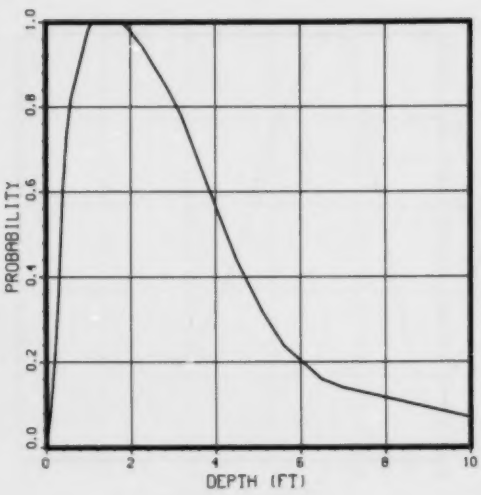



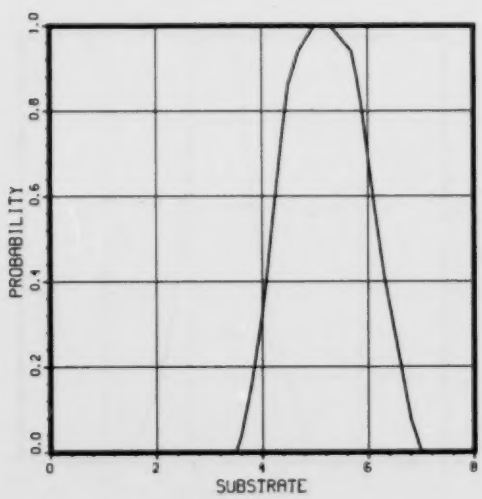



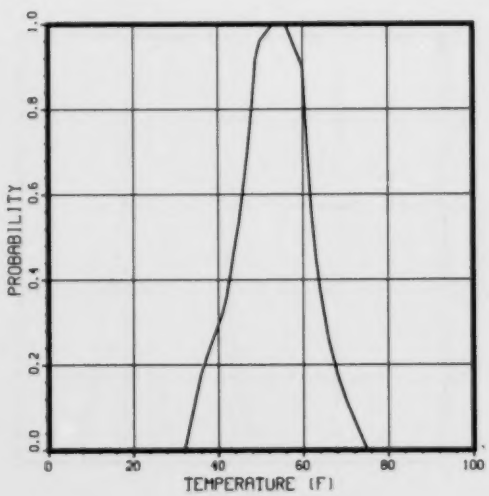
CUTTHROAT TROUT (CLEAR WATER, S=.001)

11221 INCUBATION 78/01/24.



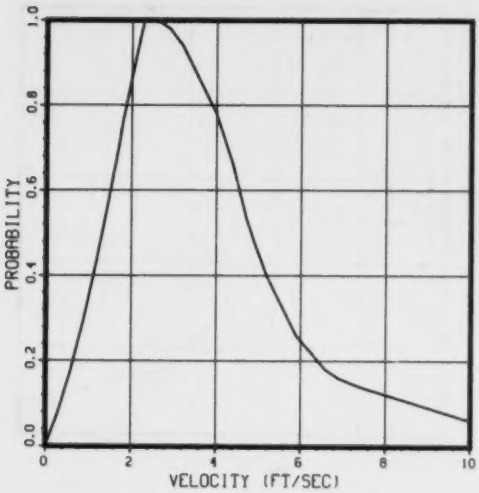



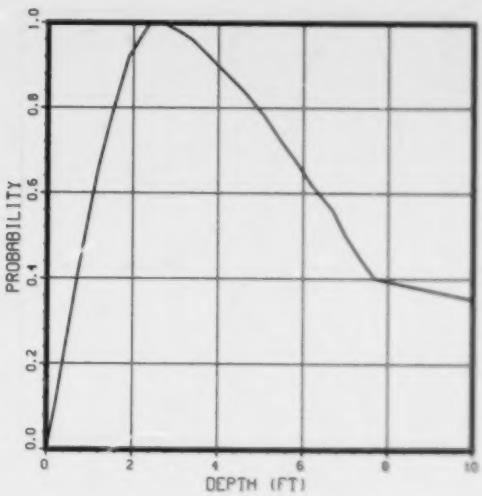



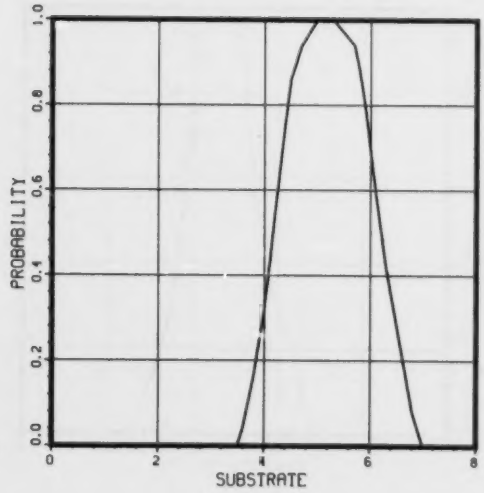



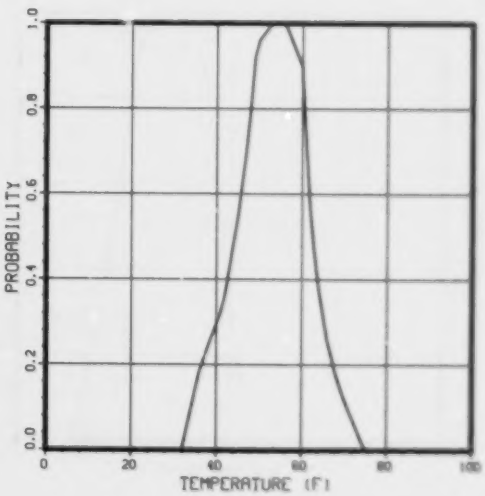
CUTTHROAT TROUT (TURBID WATER, S=.001)

11222 INCUBATION 78/01/24.



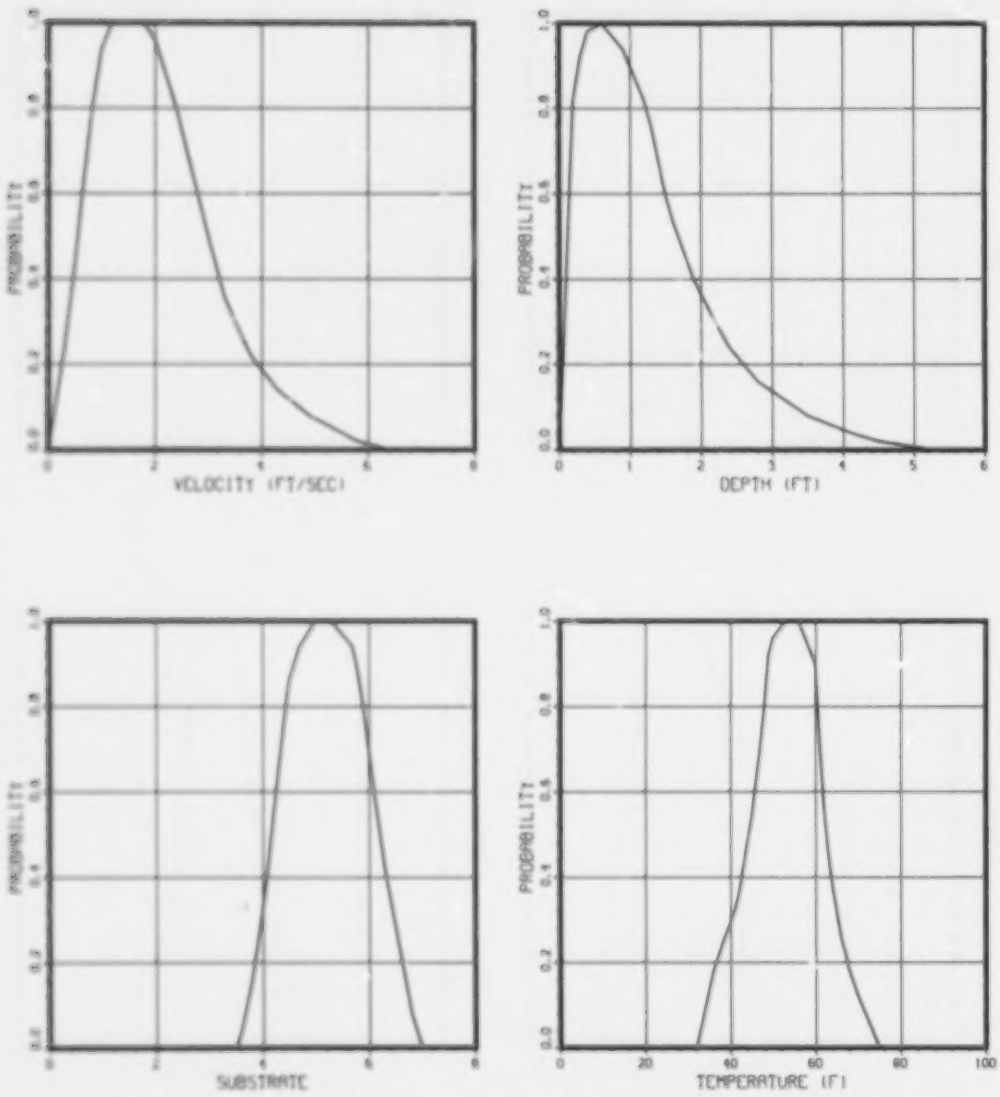



CUTTHROAT TROUT (CLEAR WATER, S=.0025)

11223 INCUBATION 78/01/24.



CUTTHROAT TROUT (TURBID WATER, S=.0025)

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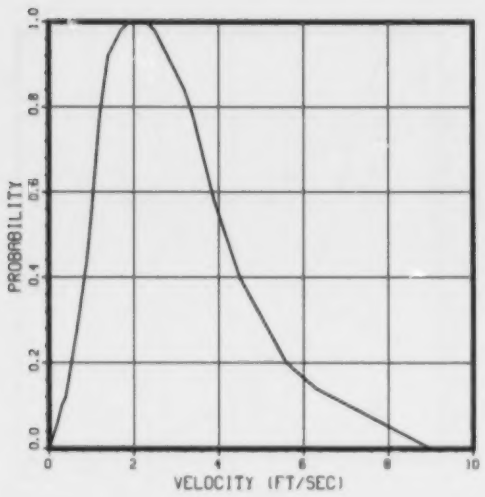
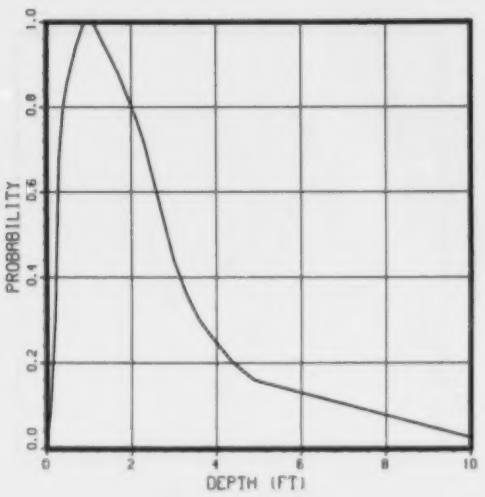
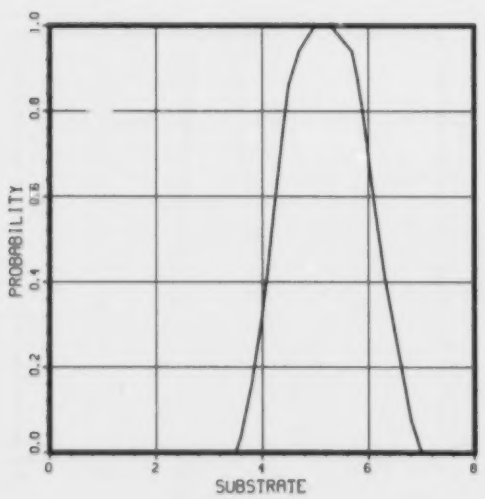
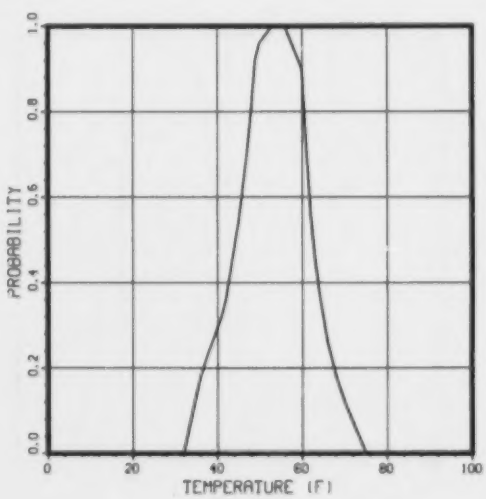


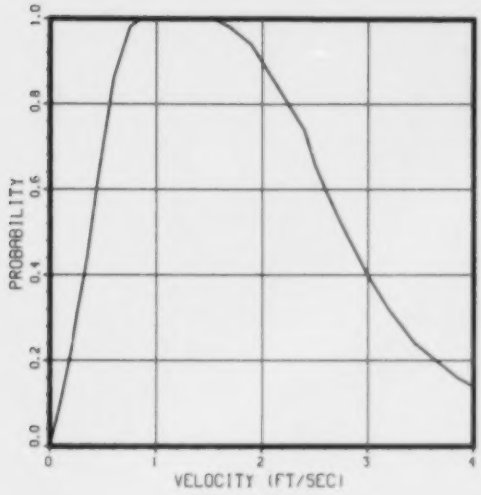



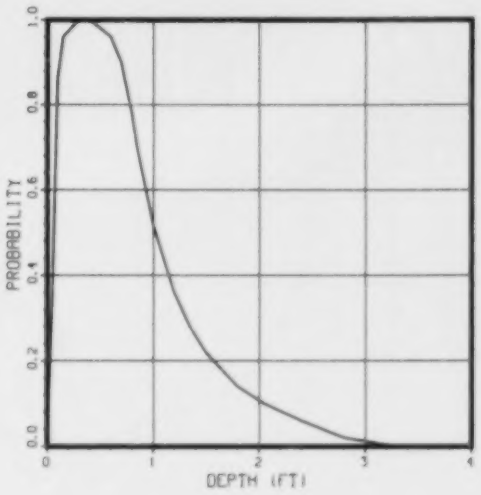



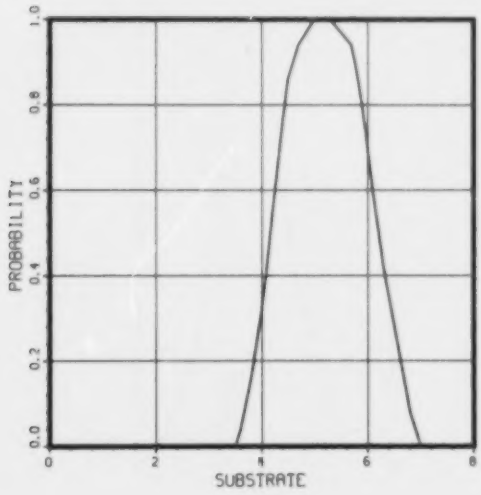



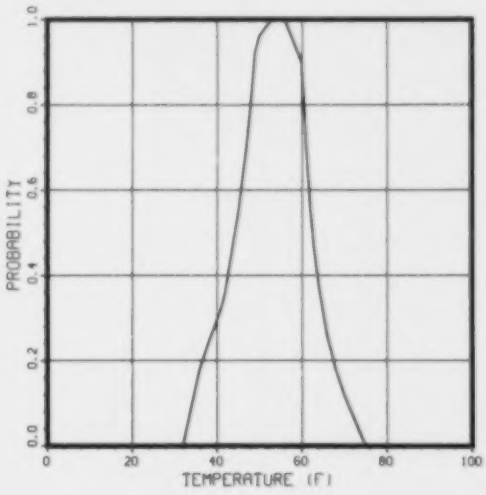
CUTTHROAT TROUT (CLEAR WATER, S=.004)

11225 INCUBATION 78/01/24.



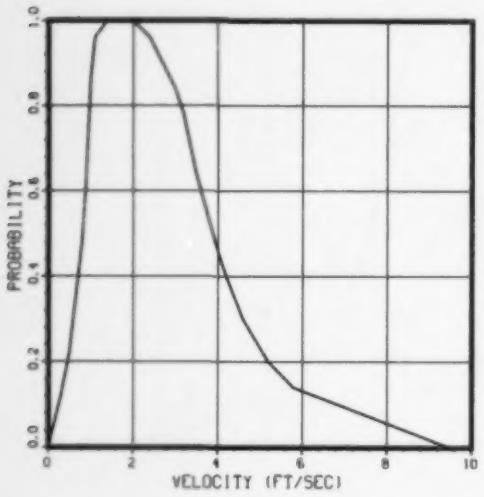



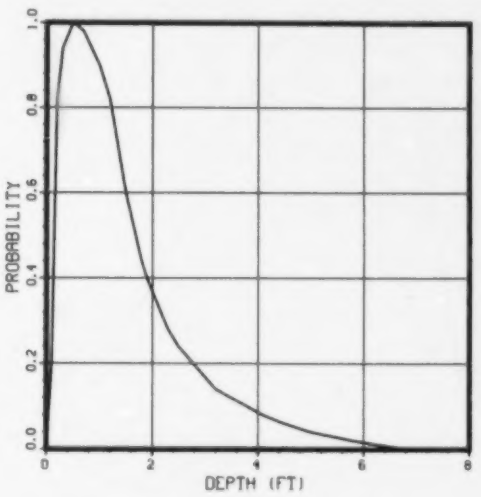



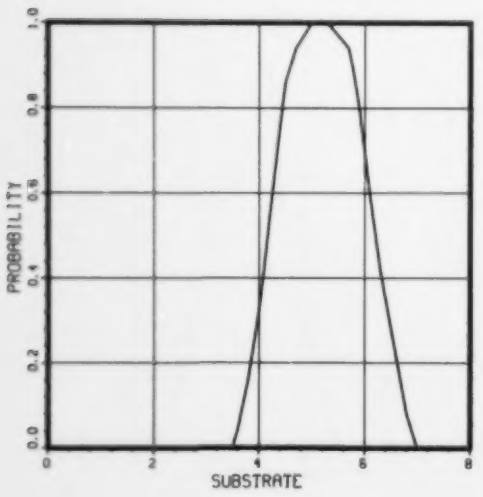



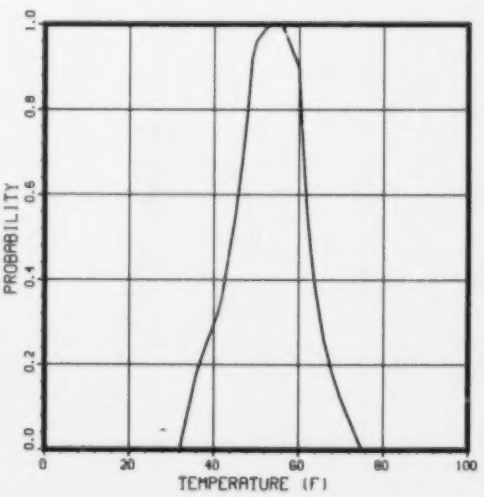
CUTTHROAT TROUT (TURBID WATER, S=.004)

11226 INCUBATION 78/01/24.



# RAINBOW TROUT

## Salmo gairdneri

| Catalog No. | 011110 Spawning | | | | 011102 Adult | | | | 011101 Juvenile | | | | 011100 Fry | | | | 01121-011126 Egg Incubation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES: Rainbow Trout | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature |
| IFG EVALUATION | E | E | G | G | F | F | F | G | E | E | E | G | G | E | E | G | F | F | G | G |
| REFERENCE | 19 RO | 19 RO | 19 RO | 2 PO | 15 FA | 15 FA | 15 FA | 27 PO | 15 FA | 15 FA | 15 FA | 27 PO | 15 FA | 15 FA | 15 FA | 4 FA | 11 IN | 11 IN | 11 IN | 8 IN |
| | 23 FA | 23 FA | 20 RO | 8 PO | 18 FA | 18 FA | 18 FA | 2 PO | 18 FA | 18 FA | 18 FA | 2 PO | 18 FA | 18 FA | 18 FA | 8 PO | 9 IN | 9 IN | 35 IN | 8 IN |
| | 28 FA | 28 FA | | 20 RO | | | | 31 PO | | | | 31 PO | | | | 31 PO | 25 IN | 25 IN | 29 IN | |
| ANALYSIS | | | | 31 PO | | | | 8 PO | | | | 8 PO | | | | | 36 IN | 36 IN | | |
| COMMENTS | | | | | | | | 2 | | | | 2 | 1 | | 2, 3 | | | | | 4 |

**Key to IFG Evaluation Matrix**

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

Reference: Refer to listed number in bibliography.

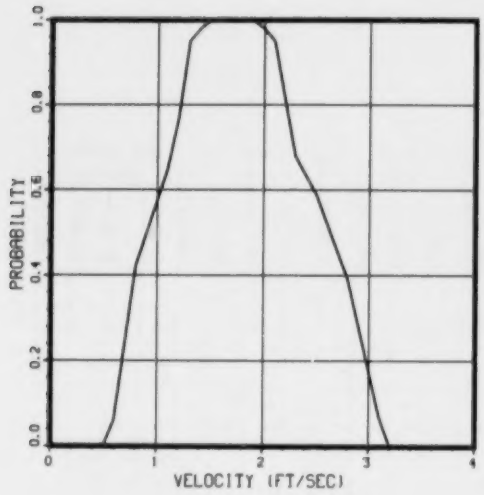
Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

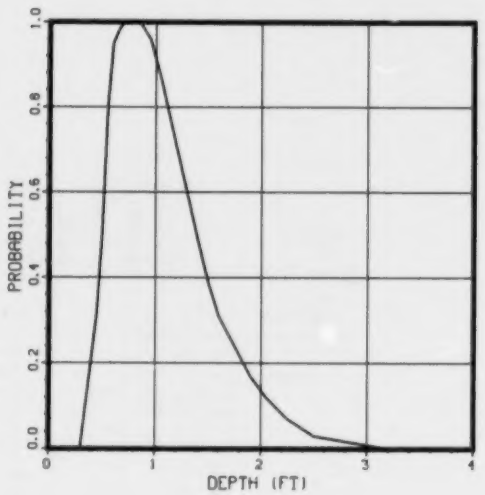
**Comments - Rainbow Trout Curves**

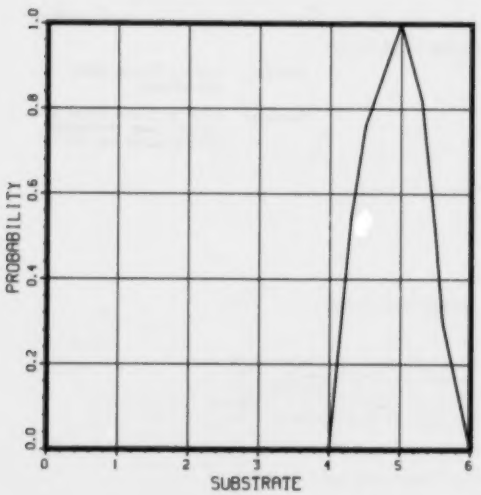
1. Multiple modes in data. Variance not removed by clustering of adjacent velocity classes. Because fry tend to school, it is possible to observe a large number of fish in relatively few types of areas; therefore, the actual sample size here is smaller than would be indicated by the number of observations (n = 524).
2. Digestion is poor at temperatures lower than 38°F.
3. Fry exhibit downstream drift at temperatures less than 55°F.
4. Probabilities of survival based on time required for hatching at different temperatures.

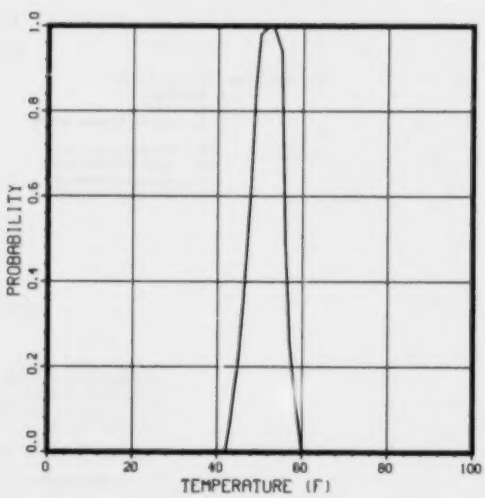
RAINBOW TROUT

11110 SPAWNING 78/01/24.



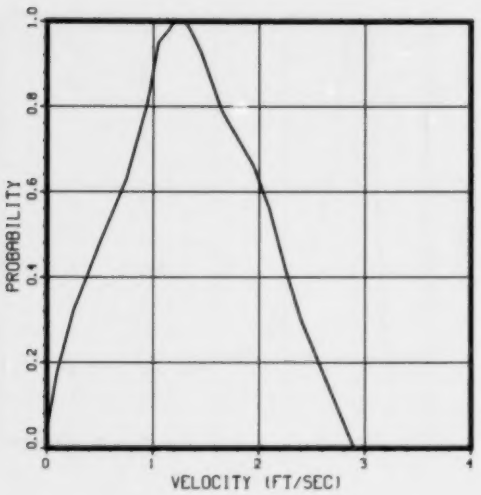



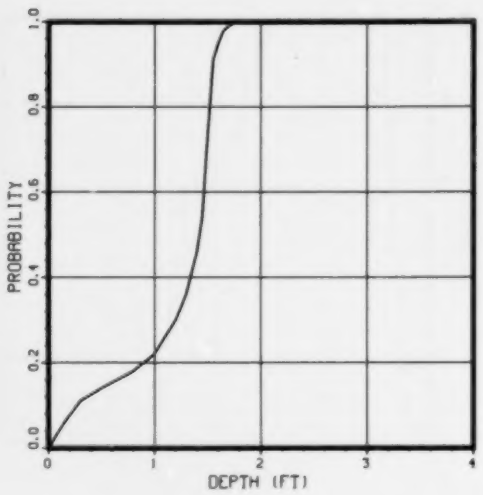



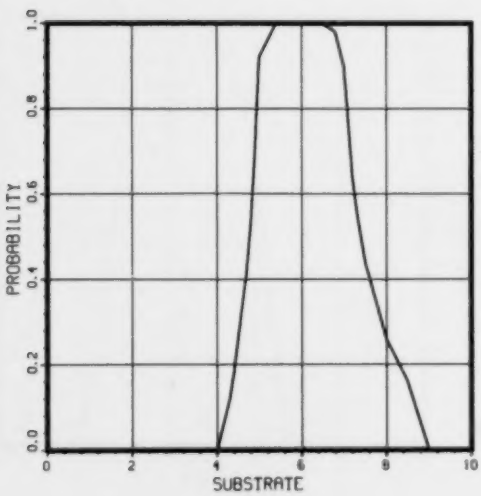



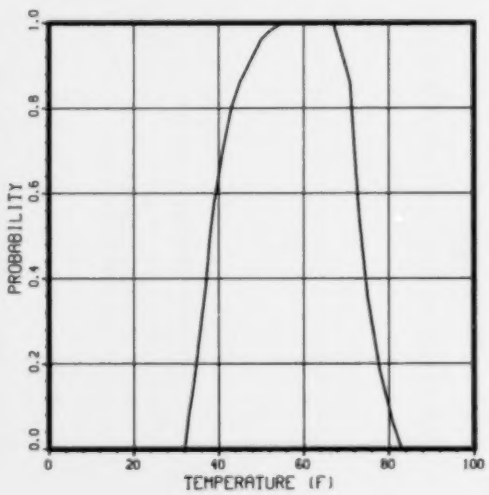
RAINBOW TROUT

11102 ADULT 78/01/24.



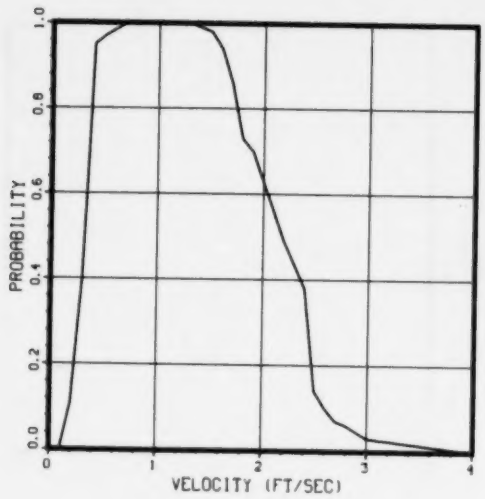



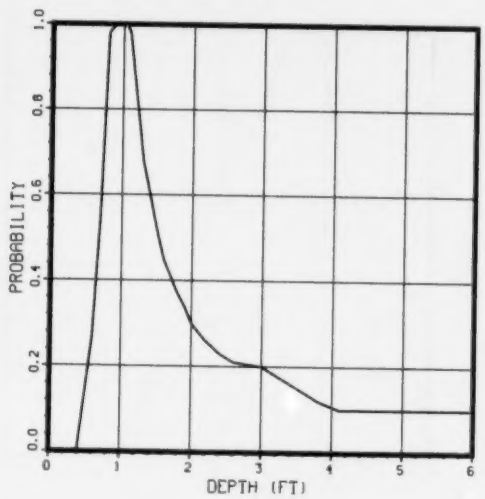



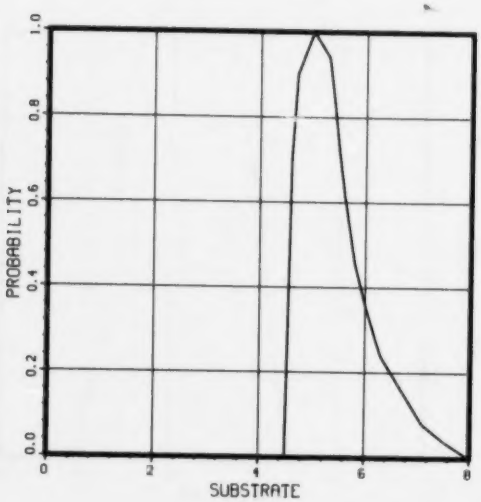



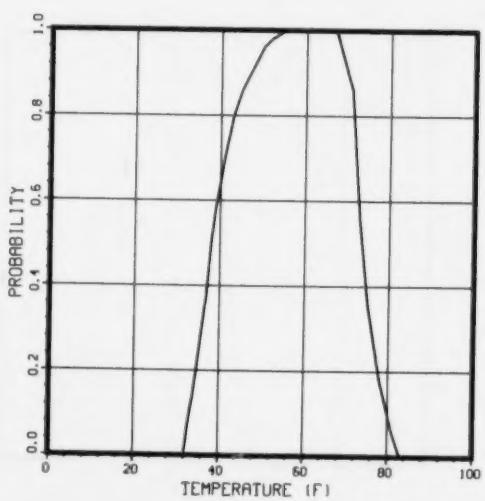
RAINBOW TROUT

11101 JUVENILES 78/01/24.



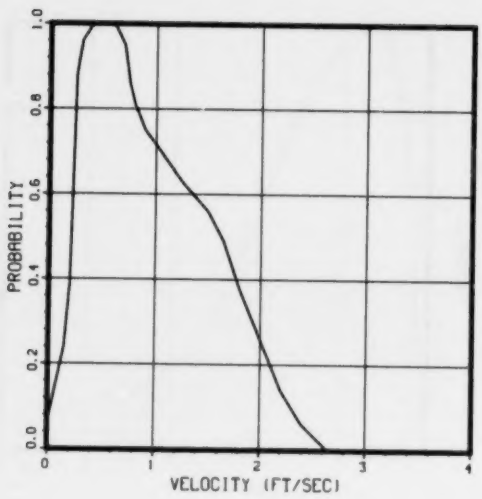



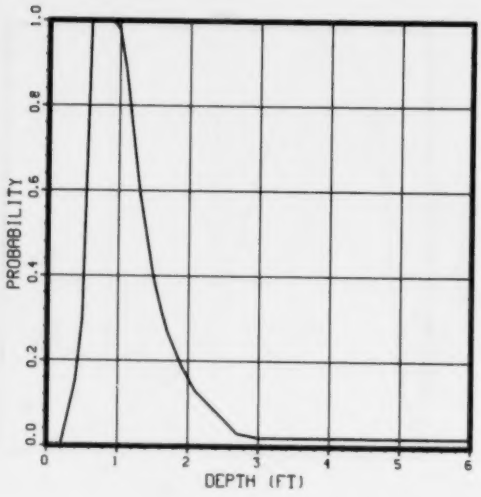



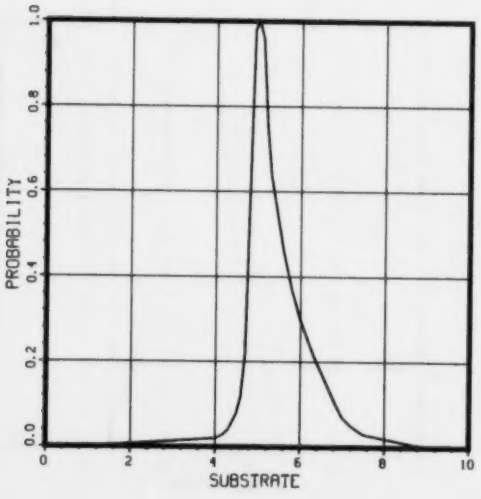



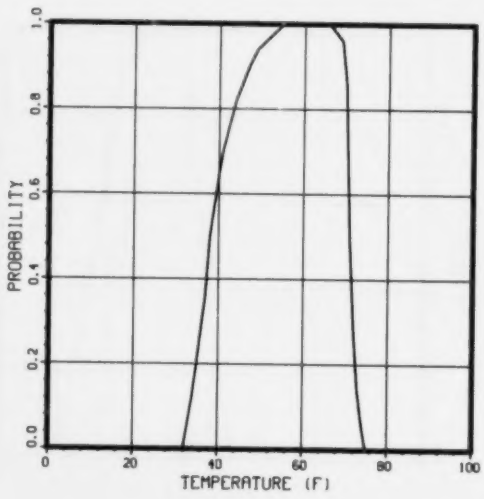
RAINBOW TROUT

11100 FRY 78/01/24.



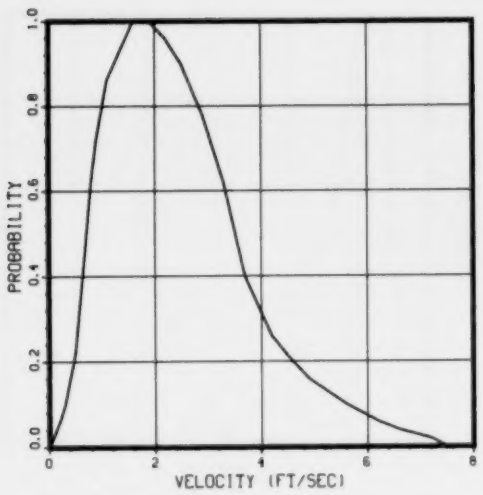



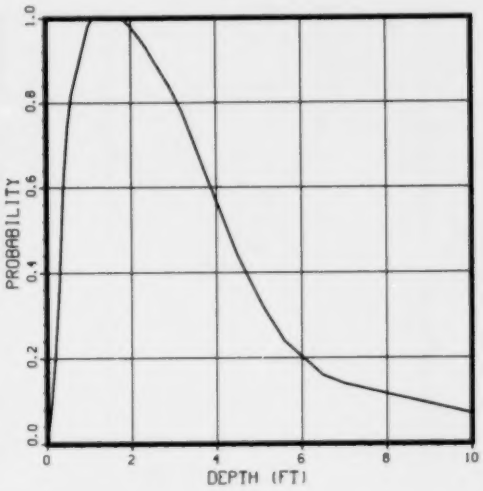



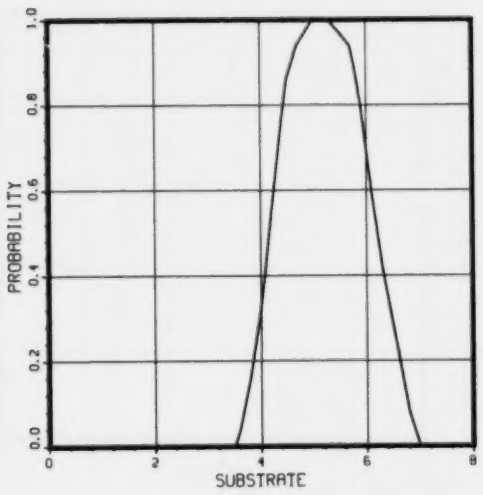



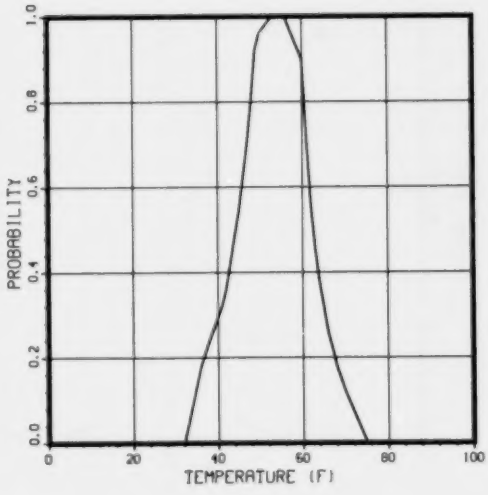
RAINBOW TROUT (CLEAR WATER, S=.001)

11121 INCUBATION 78/01/24.



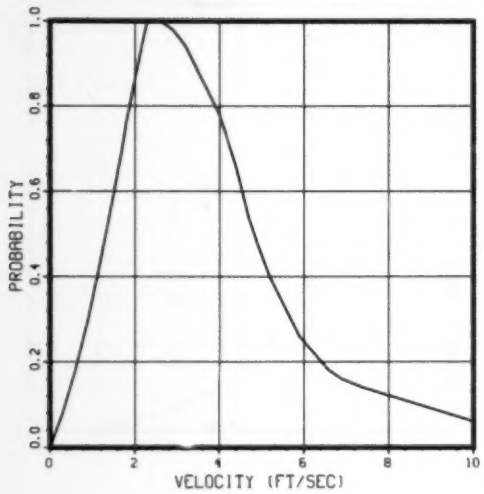



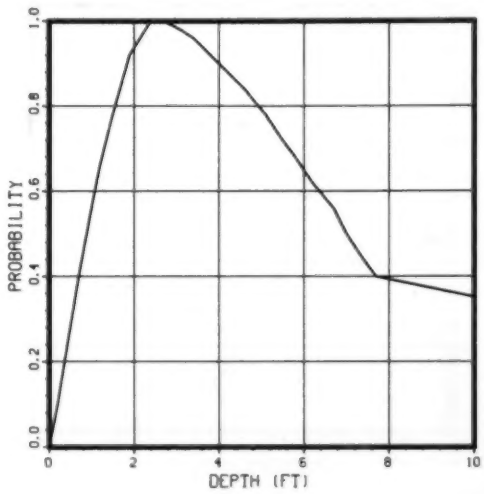



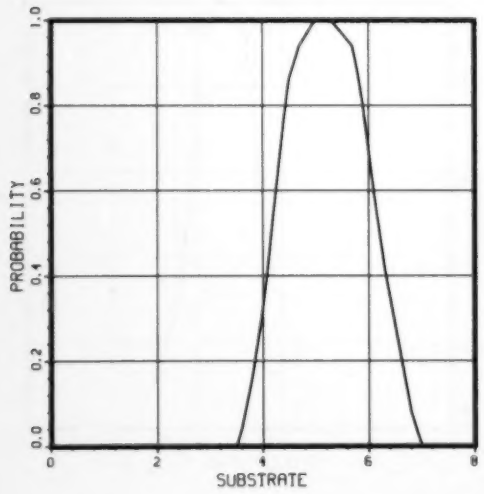



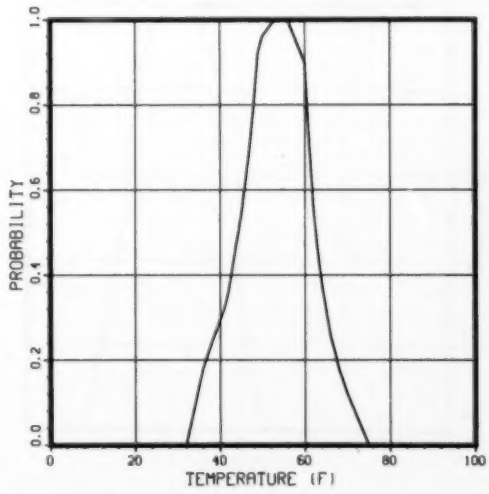
RAINBOW TROUT (TURBID WATER, S=.001)

11122 INCUBATION 78/01/24.



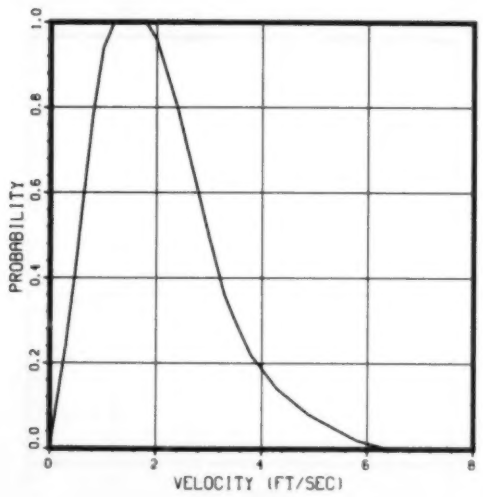



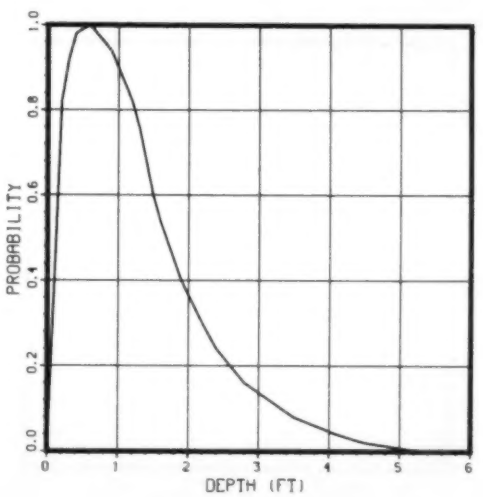



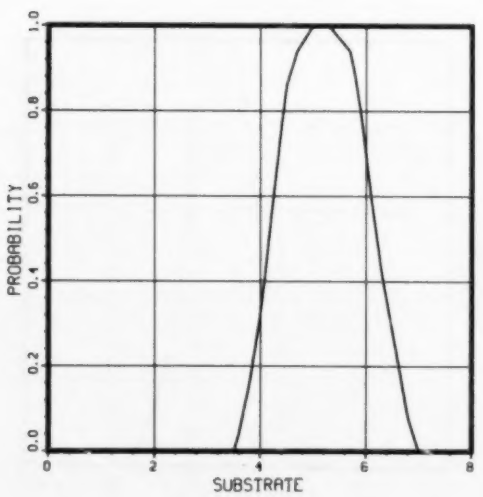



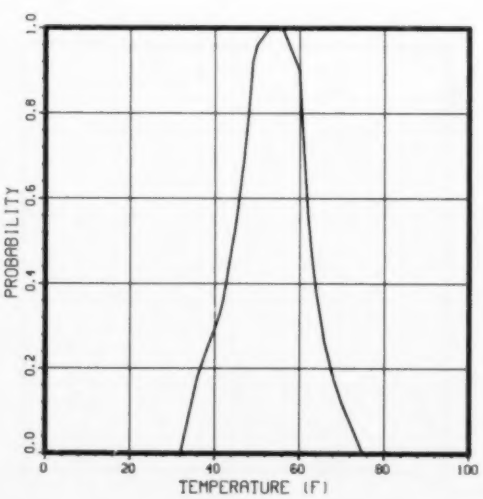
RAINBOW TROUT (CLEAR WATER, S=.0025)

11123 INCUBATION 78/01/24.



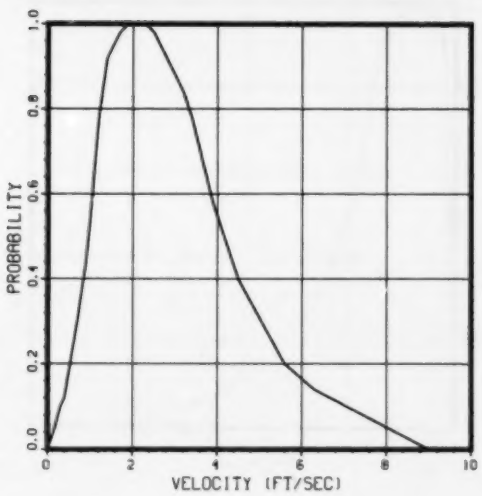



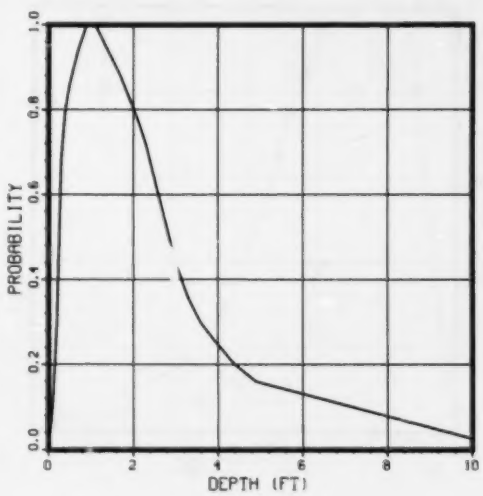



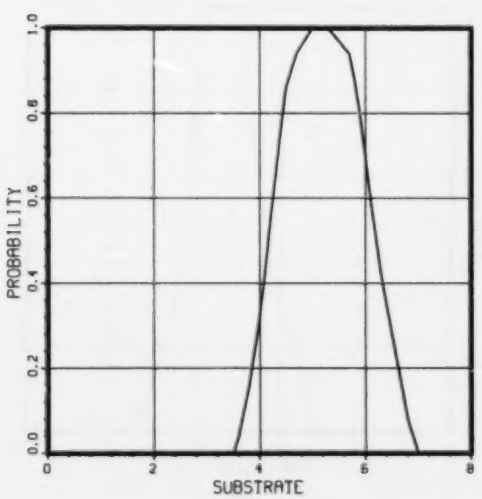



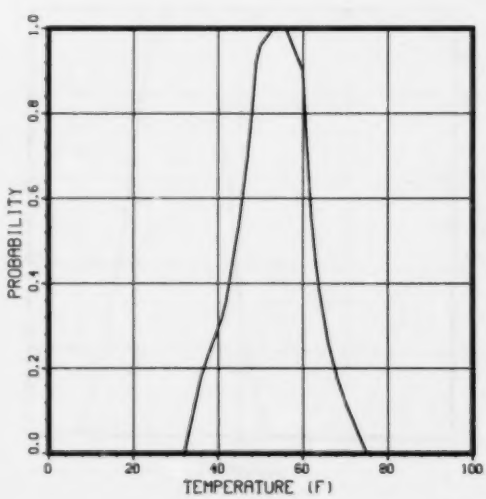
RAINBOW TROUT (TURBID WATER, S=.0025)

11124 INCUBATION 78/01/24.



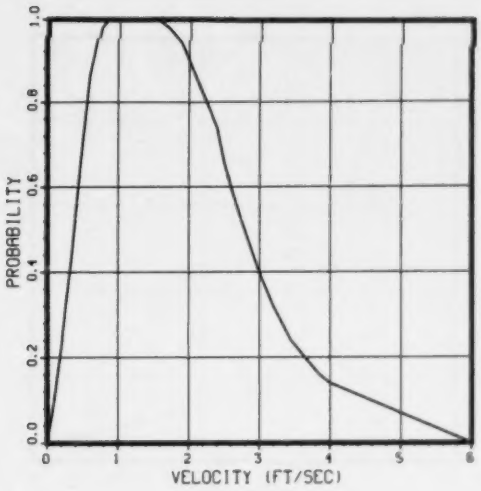



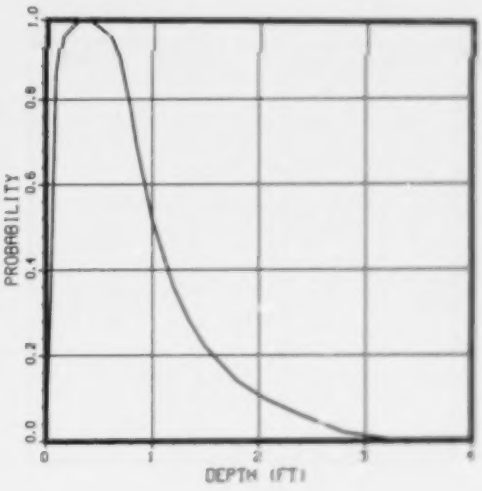



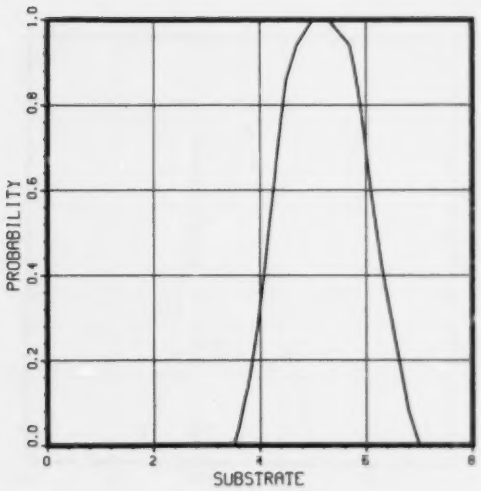



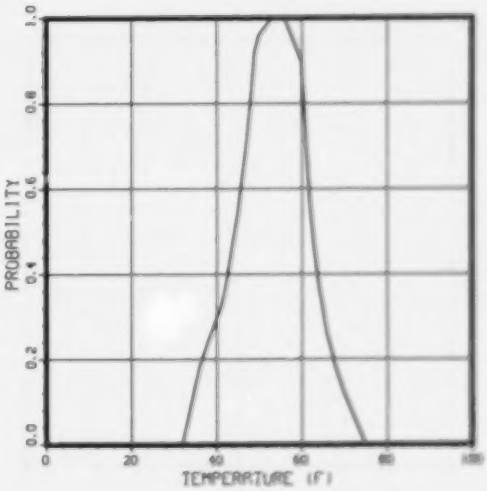
RAINBOW TROUT (CLEAR WATER, S=.004)

11125 INCUBATION 78/01/24.



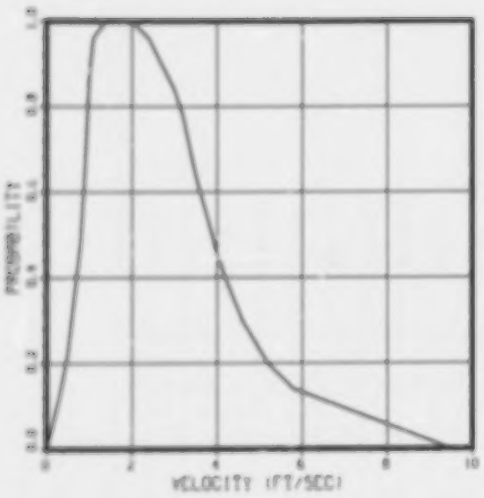



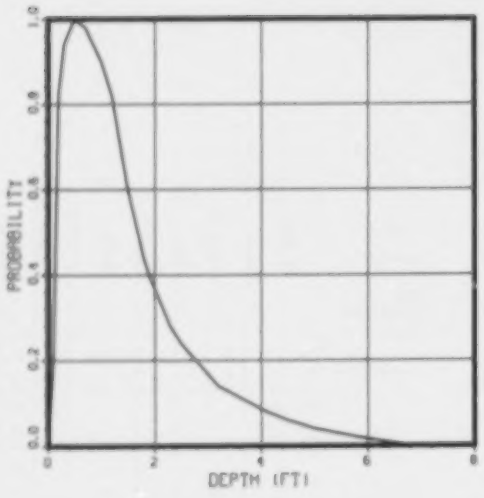



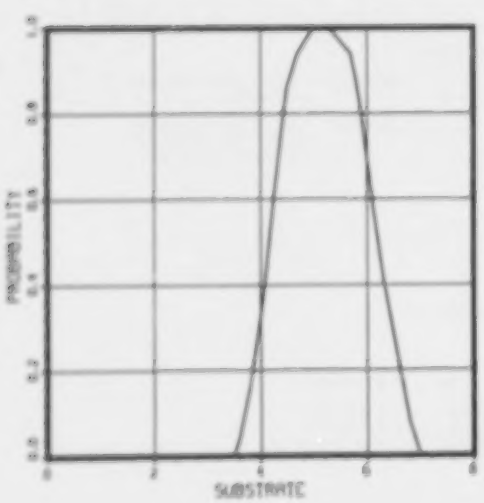



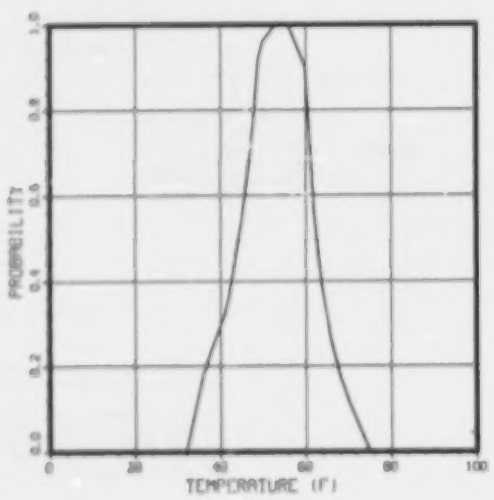
RAINBOW TROUT (TURBID WATER, S=.004)

11126 INCUBATION 78/01/24.



# STEELHEAD

## Salmo gairdneri

| Catalog No. | 11013 Spawning | | | | 11002 Adult | | | | 11001 Juvenile | | | | 11000 Fry | | | | 11021-11026 Egg Incubation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES: Steelhead | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature |
| IFG EVALUATION | E | E | G | G | F | F | F | F | G | G | G | F | G | G | G | F | F | G | F | R |
| REFERENCE | 22 FA | 22 FA | 28 FA | 22 PO | 18 FA | 18 FA | 18 FA | 15 PO | 14 FA | 14 FA | 14 FA | 15 PO | 14 FA | 14 FA | 14 FA | 15 PO | 9 IN | 9 IN | 11 IN | 21 RO |
| | 28 FA | 28 FA | | | | | | | 17 RO | 17 RO | 17 RO | | 17 RO | 17 RO | 17 RO | | 11 IN | 11 IN | 36 IN | |
| | | | | | | | | | 18 FA | 18 FA | 18 FA | | 18 FA | 18 FA | 18 FA | | 25 IN | 25 IN | | |
| ANALYSIS | | | | | | | | | | | | | | | | | 36 IN | 36 IN | | |
| COMMENTS | | | | | | | | | 1 | 1 | 2 | | 1 | 1 | | | | | | |

**Key to IFG Evaluation Matrix**

**IFG Evaluation:** E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

**Analysis:** FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

**Reference:** Refer to listed number in bibliography.

**Comments:** Refer to listed number on comment sheet (following IFG Evaluation Matrix).

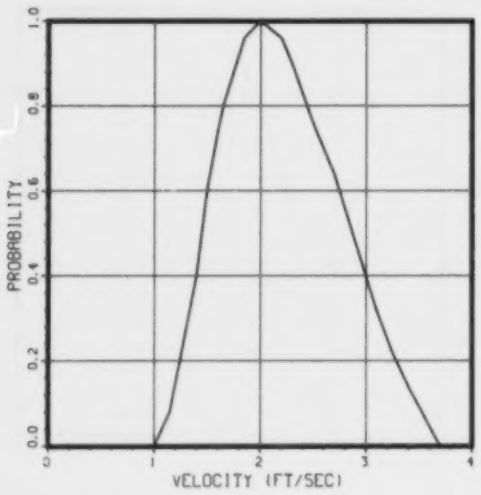
**Comments - Winter Steelhead**

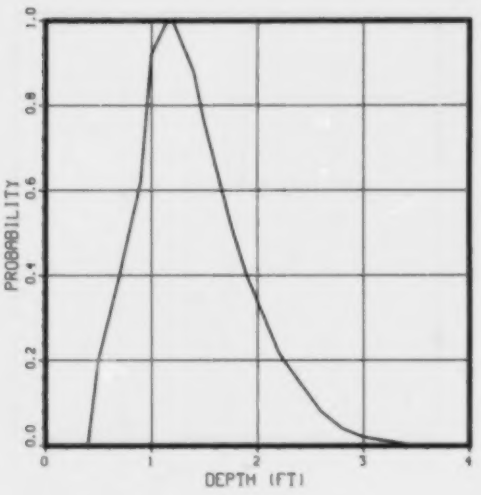
1. Frequency Analysis from Everest and Chapman utilized density rather than frequency of observation. Sample size unknown.

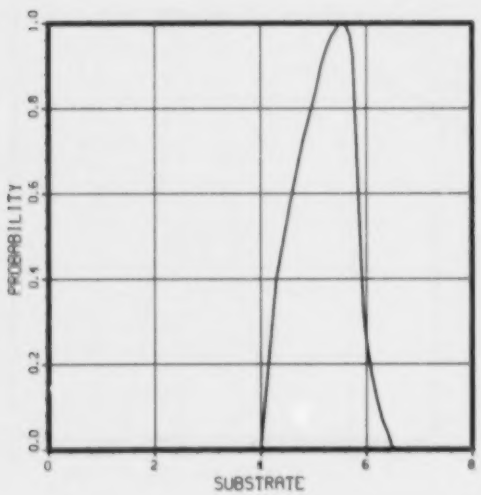
2. Everest and Chapman show conflicting data. In one study section tl. / found steelhead pre-smolts over a silt bottom, but not so in two others. These two agreed well with the data provided by Hanson. Data from the conflicting stream reach was not used in the analysis.

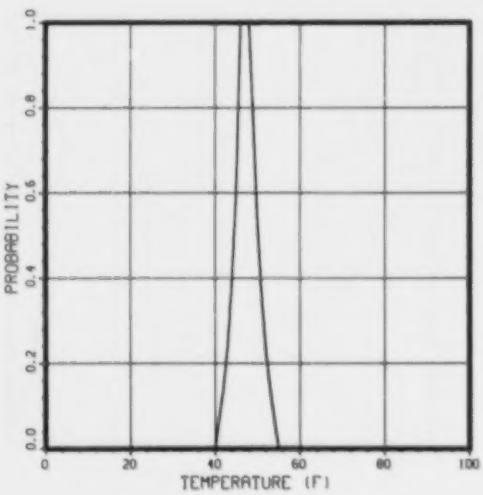
WINTER STEELHEAD

11010 SPAWNING 78/01/24.



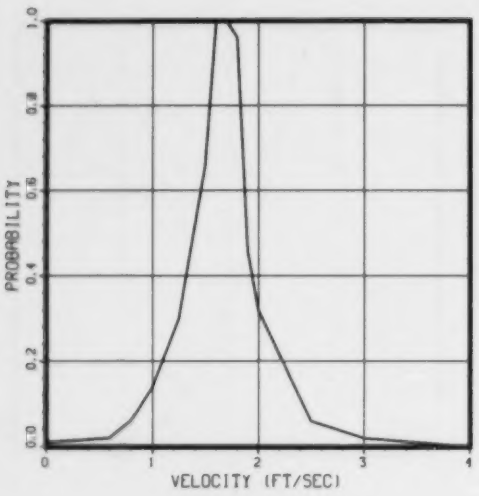



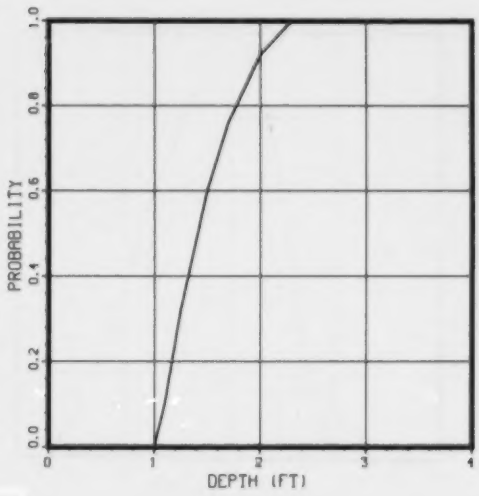



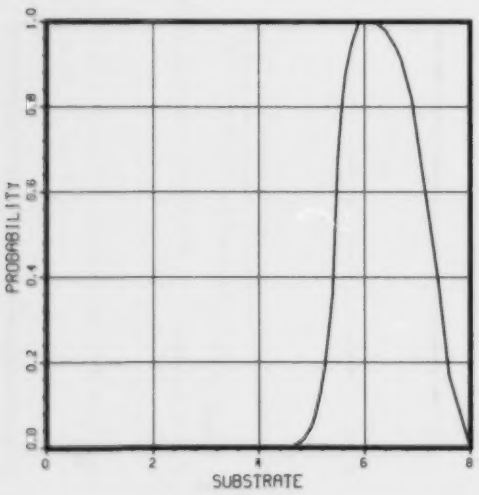



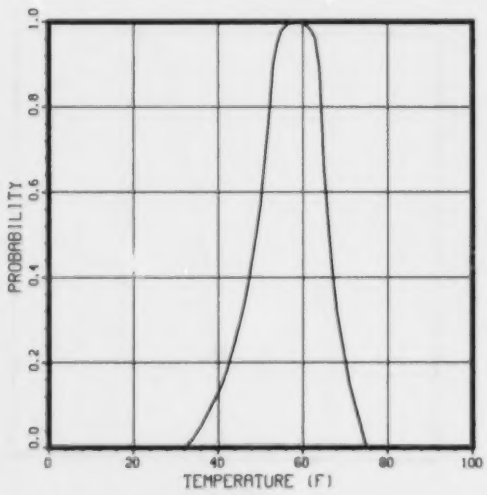
# WINTER STEELHEAD

11002 ADULT 78/01/24.



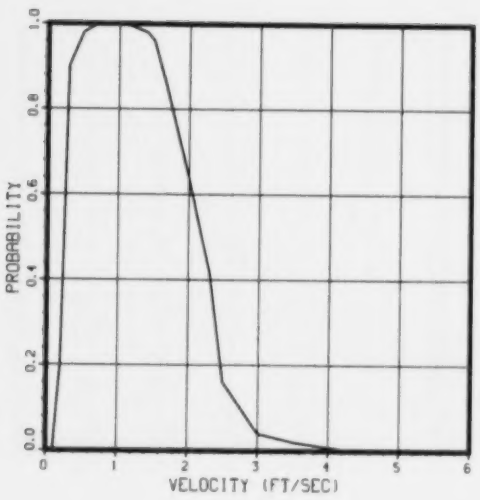



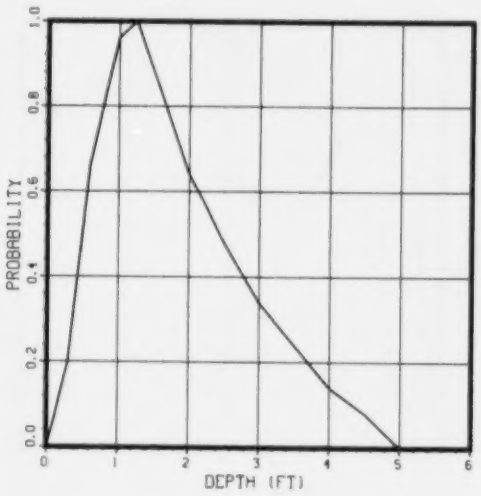



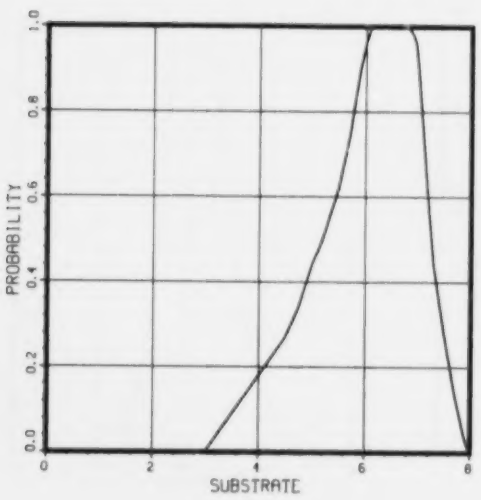



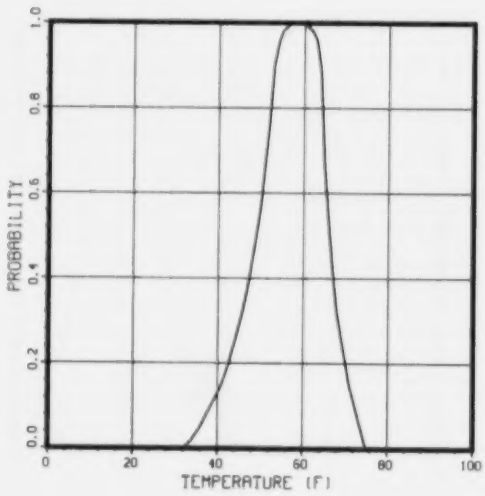
WINTER STEELHEAD

11001 JUVENILE 78/01/24.



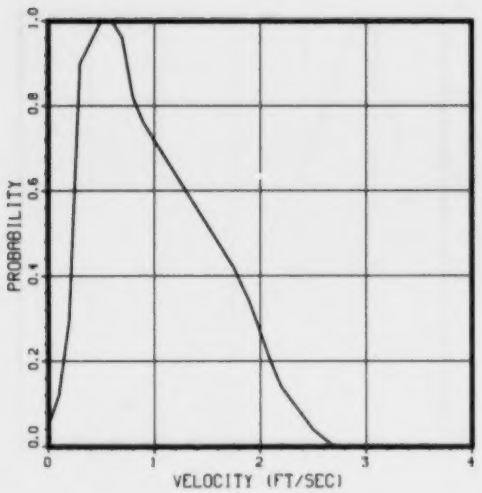



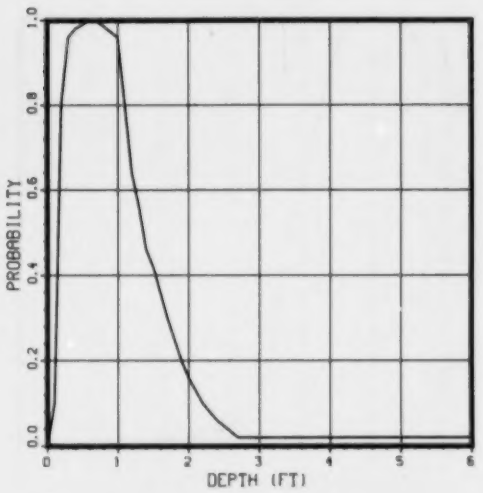



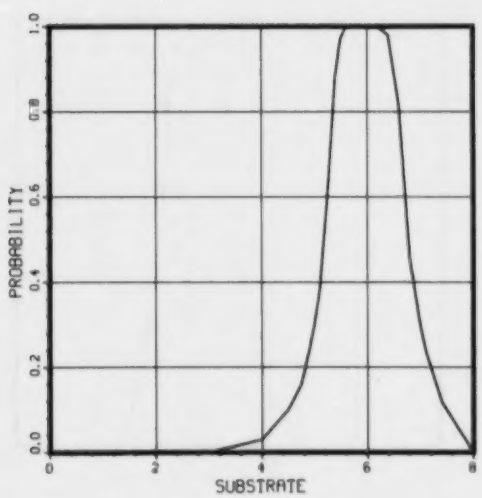



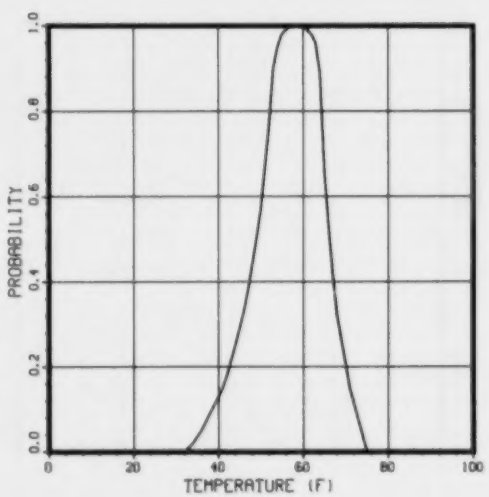
WINTER STEELHEAD

11000 FRY 78/01/24.



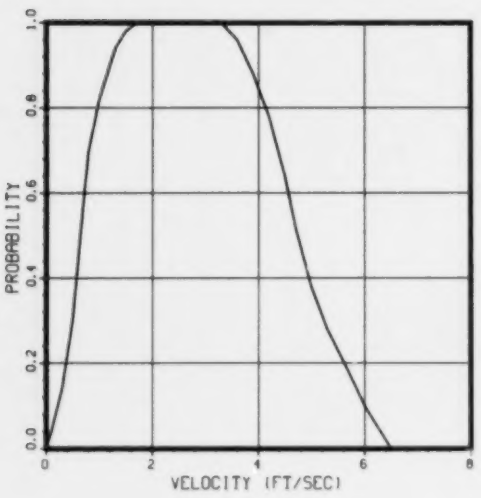



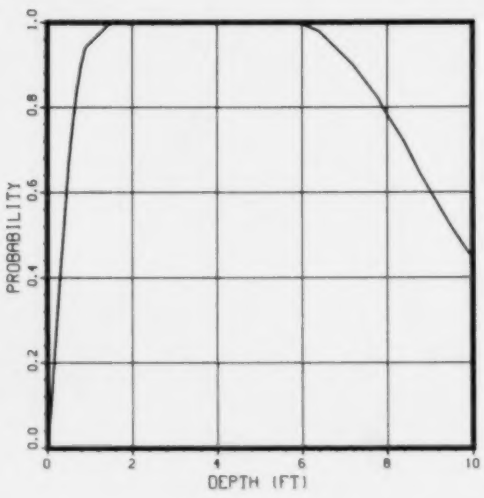



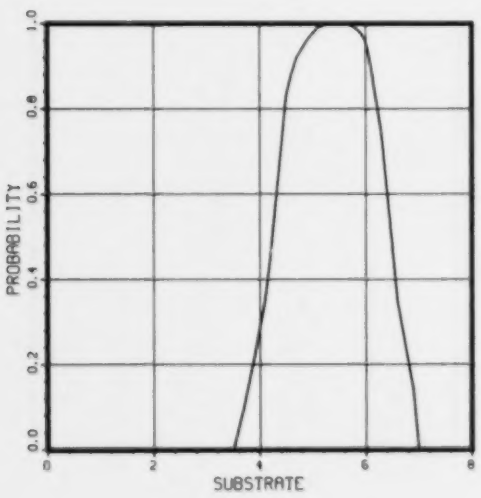



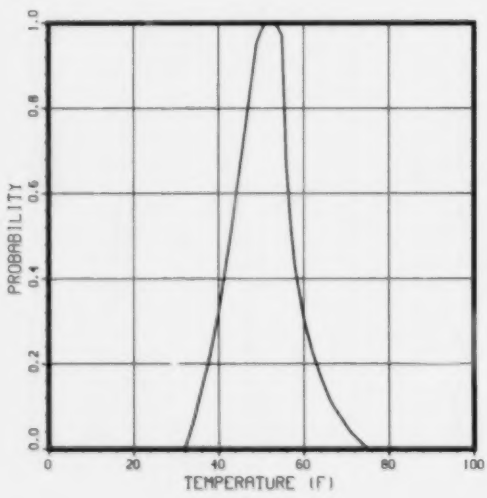
WINTER STEELHEAD (CLEAR WATER, S=.001)

11021 INCUBATION 78/01/24.



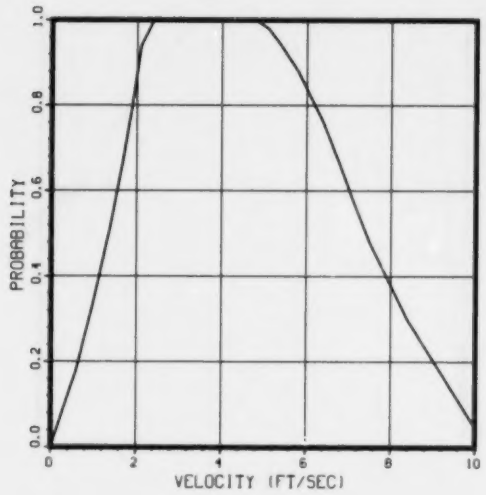



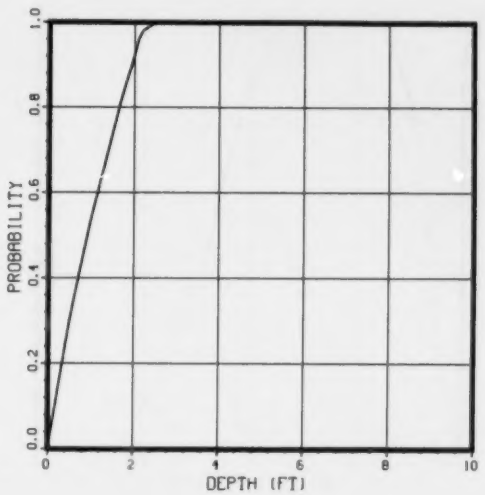



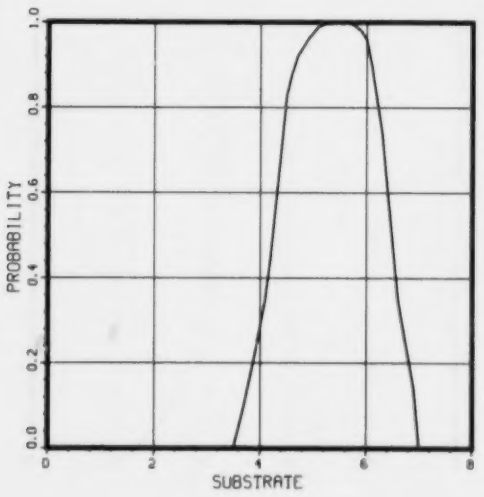



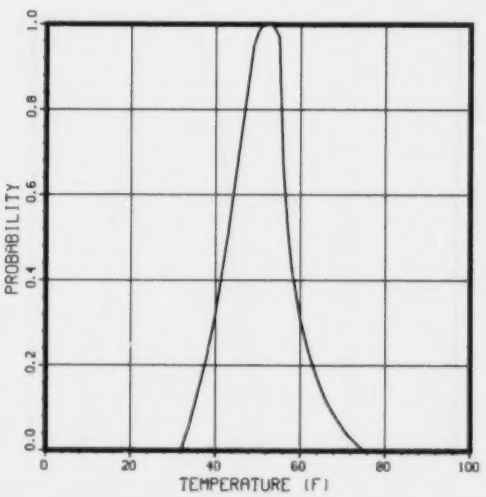
WINTER STEELHEAD (TURBID WATER, S=.001)

11022 INCUBATION 78/01/24.



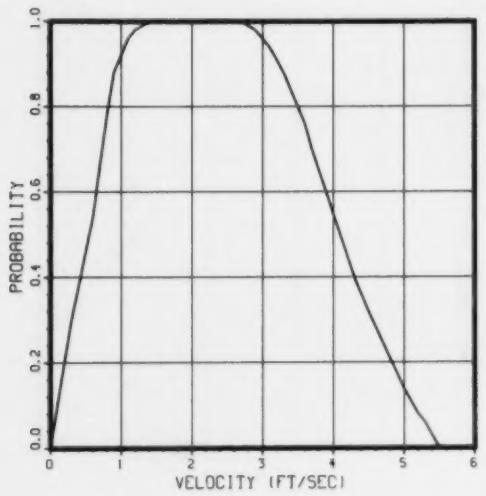



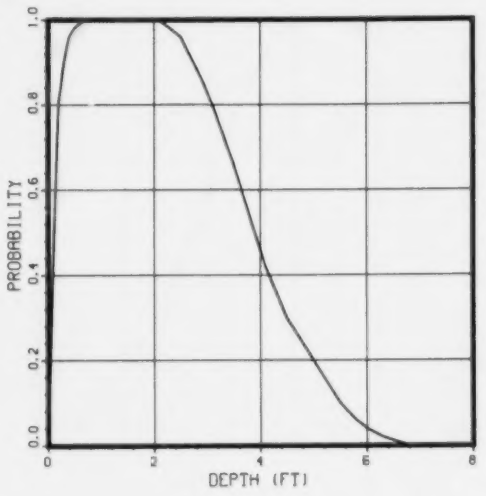



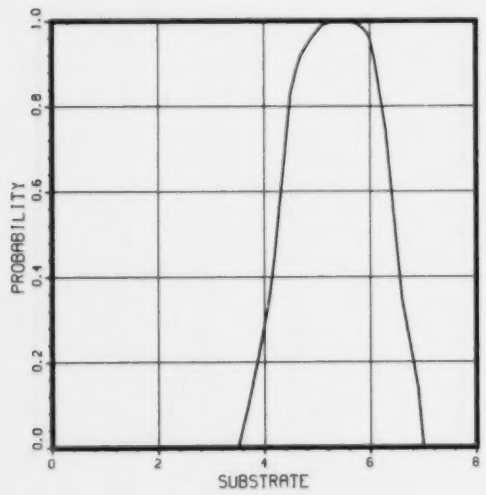



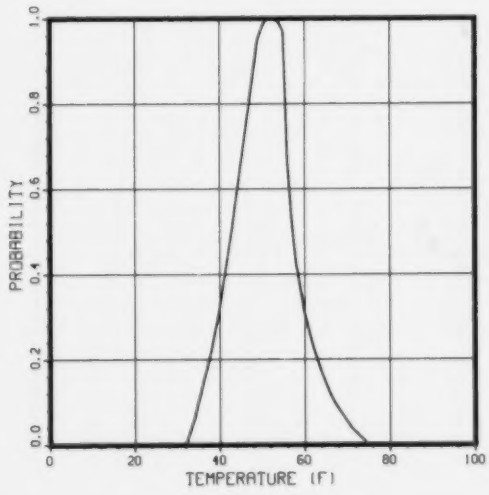
WINTER STEELHEAD (CLEAR WATER, S=.0025)

11023 INCUBATION 78/01/24.



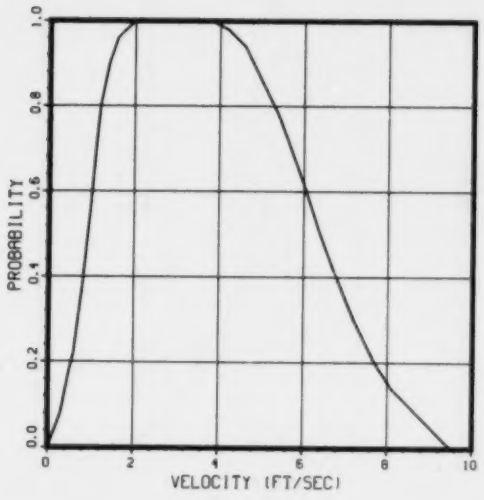



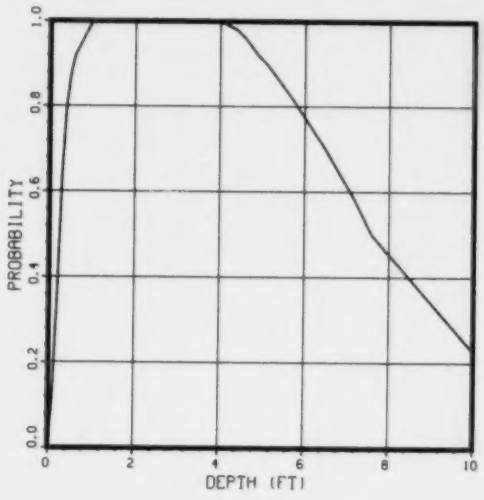



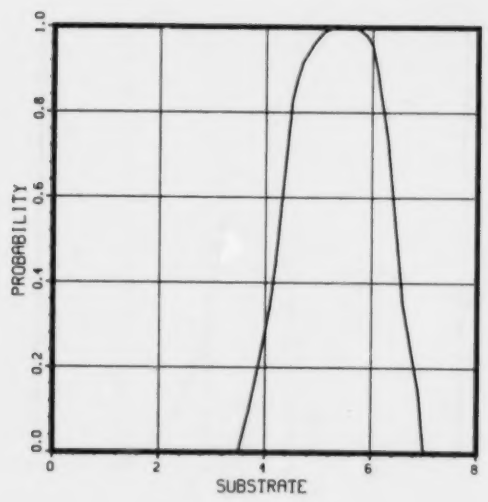



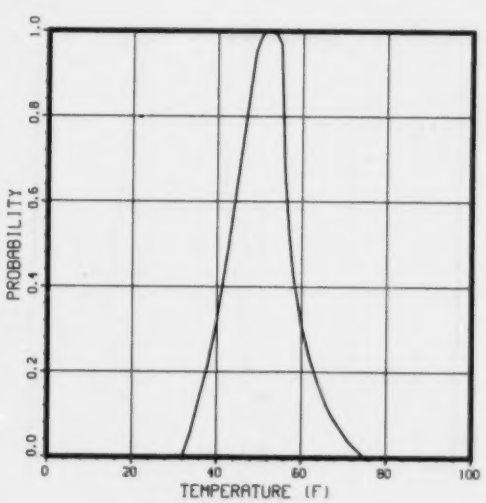
WINTER STEELHEAD (TURBID WATER, S=.0025)

11024 INCUBATION 78/01/24.



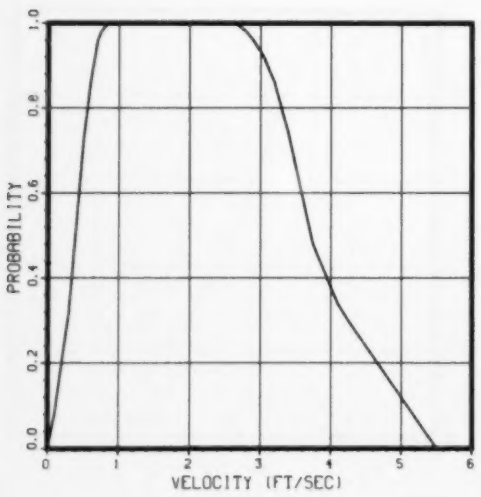



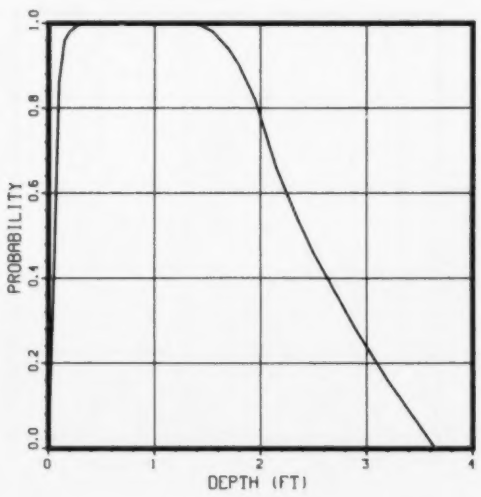



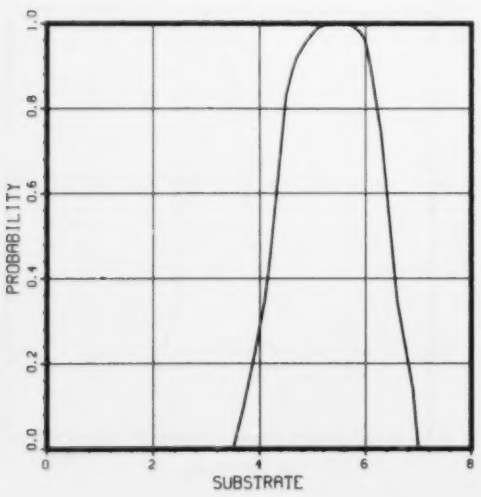



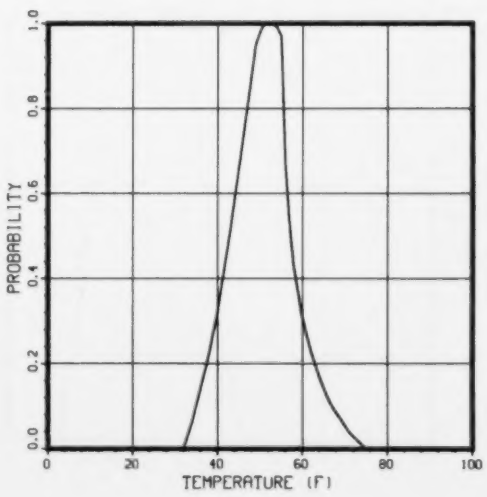
WINTER STEELHEAD (CLEAR WATER, S=.004)

11025 INCUBATION 78/01/24.



WINTER STEELHEAD (TURBID WATER, S=.004)

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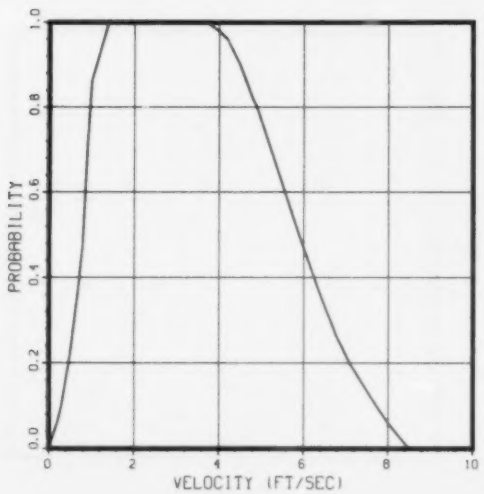
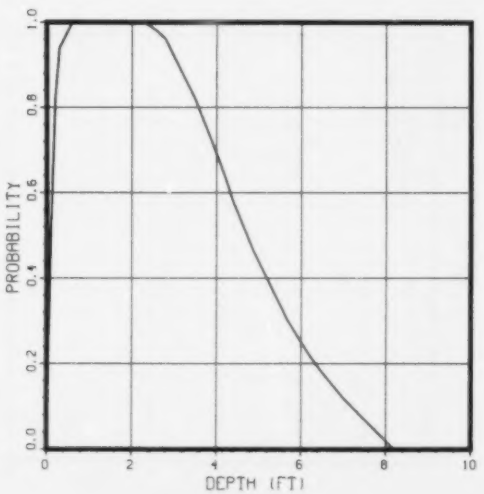
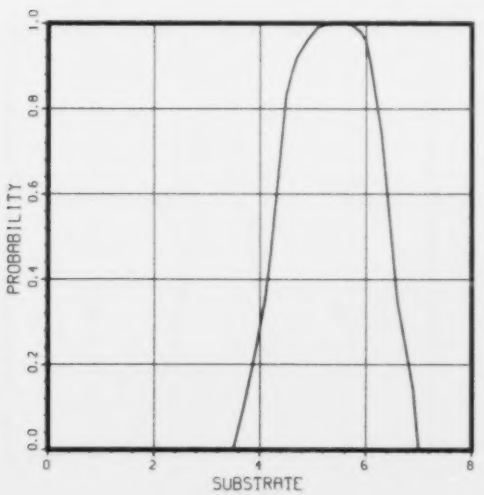
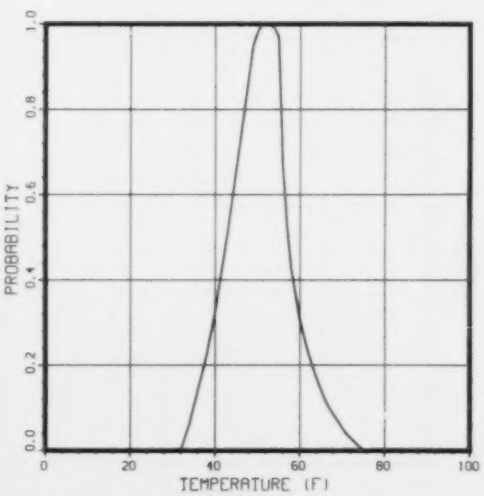


# BROWN TROUT

## Salmo trutta

| Catalog No. | 11310 Spawning | | | | 11302 Adult | | | | 11301 Juvenile | | | | 11300 Fry | | | | 11321-11326 Egg Incubation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES: Brown Trout | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature |
| IFG EVALUATION | E | E | G | G | G | G | E | G | F | F | E | G | F | G | G | G | F | F | G | F |
| REFERENCE | 29 | 29 | 29 | 20 | 12 | 12 | 12 | 2 | 12 | 12 | 12 | 2 | 12 | 12 | 12 | 2 | 9 | 9 | 11 | 2 |
| | FA | FA | FA | RO | FA | FA | FA | RO | FA | FA | FA | RO | FA | FA | FA | RO | IN | IN | IN | IN |
| | 33 | 33 | 33 | 31 | 16 | 16 | 16 | 13 | 16 | 16 | 16 | 13 | 16 | 16 | 16 | 8 | 11 | 11 | 29 | 8 |
| | FA | FA | FA | RO | FA | FA | FA | RO | FA | FA | FA | RO | FA | FA | FA | RO | IN | IN | IN | IN |
| | | | | | 3 | | | 31 | | | | 31 | | | | 13 | 25 | 25 | 36 | 30 |
| | | | | | RO | | | PO | | | | PO | | | | RP | IN | IN | IN | IN |
| ANALYSIS | | | | | | | | 8 | | | | 8 | | | | | 36 | 36 | | |
| | | | | | | | | RO | | | | RO | | | | | IN | IN | | |
| COMMENTS | | | | | | | | | | 1 | | | 2 | | | | | | | 3 |

**Key to IFG Evaluation Matrix**

**IFG Evaluation:** E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

**Analysis:** FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

**Reference:** Refer to listed number in bibliography.

**Comments:** Refer to listed number on comment sheet (following IFG Evaluation Matrix).

Comments - Brown Trout Curves

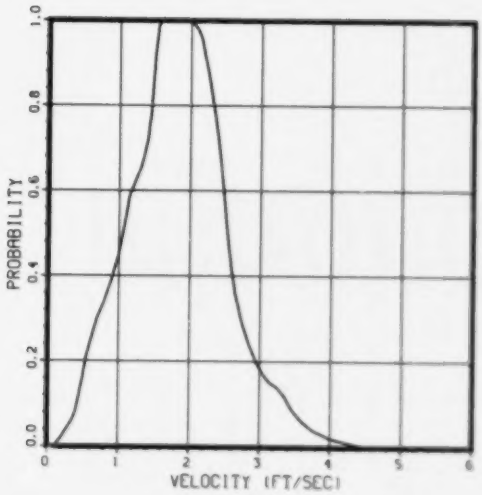
1. The mode for Wesche's data was from .5 to 1.25 feet in depth. Cochnauer's data showed no difference between 1.0 and 3.0 feet. Gosse, et. al., showed a very distinct peak at 2.9 to 3.1 feet. The optimum on this curve incorporates these differences, which may be due to availability of different conditions rather than differential preferences.

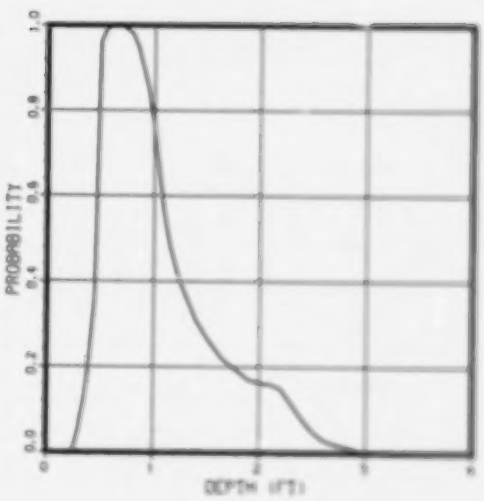
2. At the time of year that these collections were made, young of the year brown trout were fairly large. For fry recently emerged from the redds, this curve would be compacted toward the zero velocity axis somewhat.

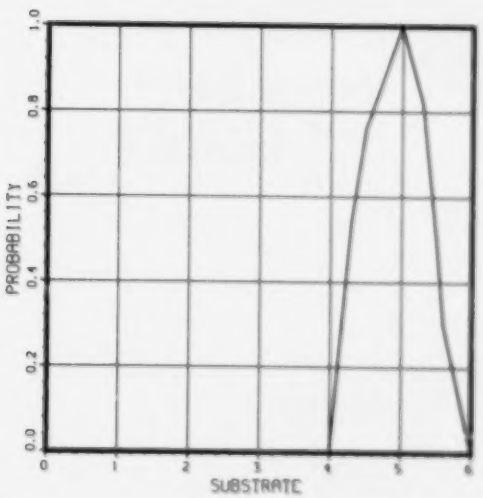
3. Survival rates were calculated from time-to-hatching data, based on a standard hatching time of 4 to 6 weeks. It was assumed that an extended incubation period would increase the probability of egg mortality. This assumption applies only to the lower temperature limb of the curve.

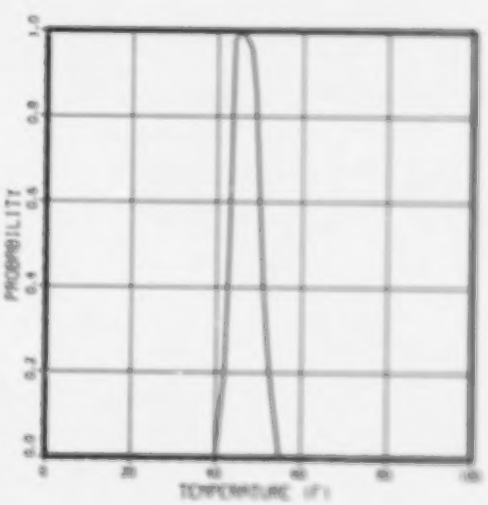
BROWN TROUT

11310 SPAWNING 78/01/24.



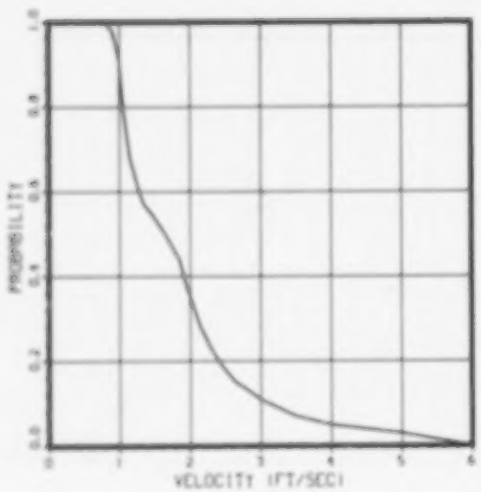



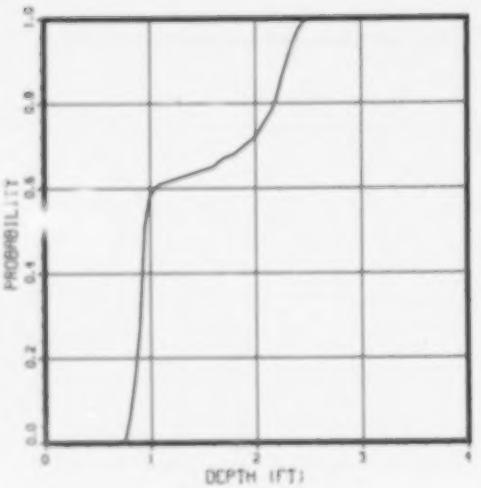



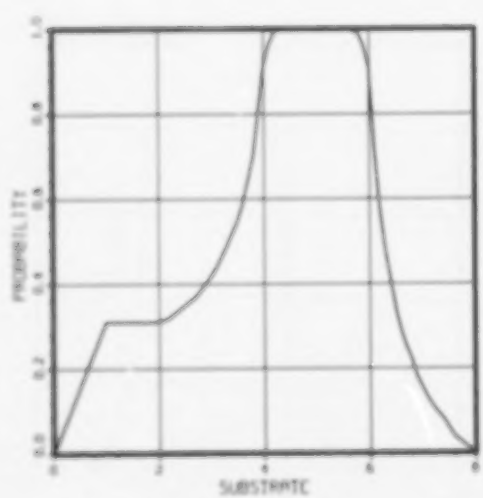



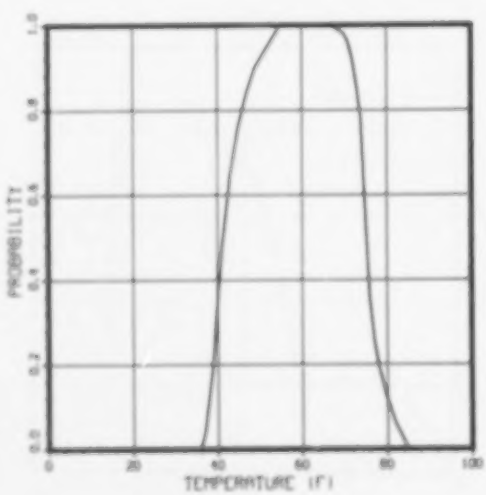
BROWN TROUT

11302 ADULTS 78/01/24.



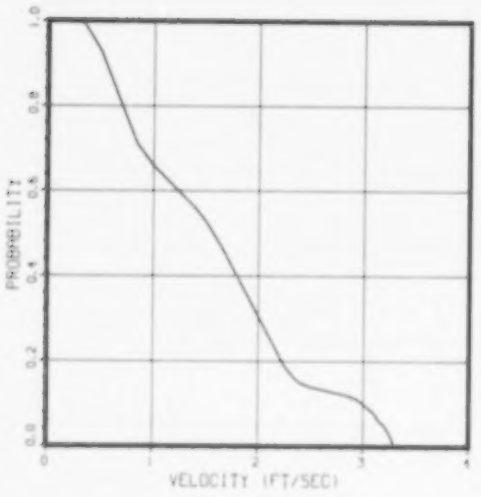



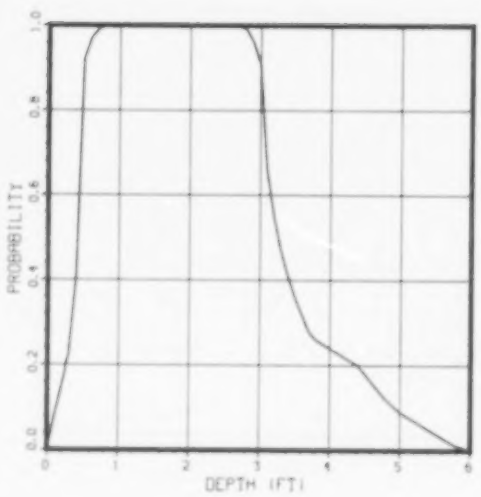



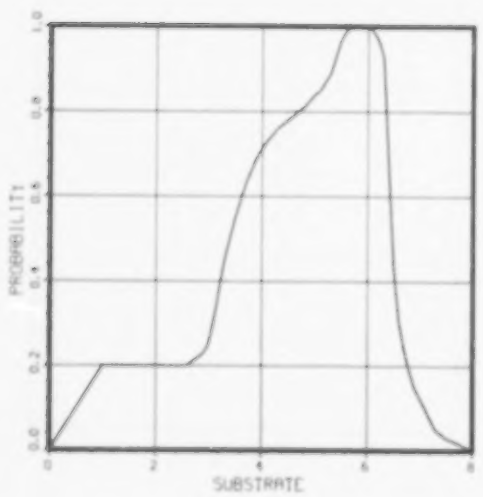



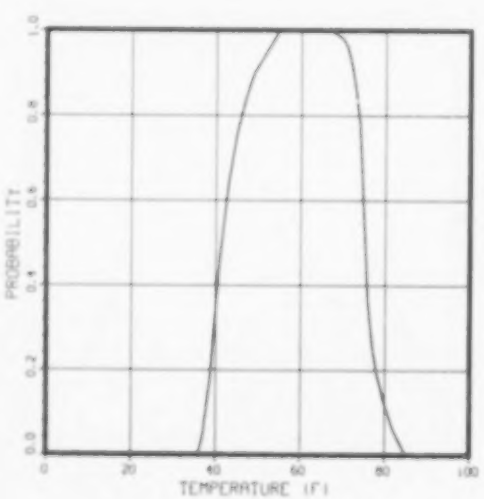
BROWN TROUT

11301 JUVENILE 78/01/24.



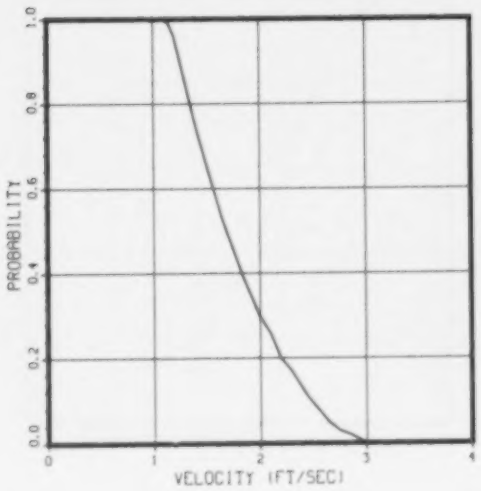



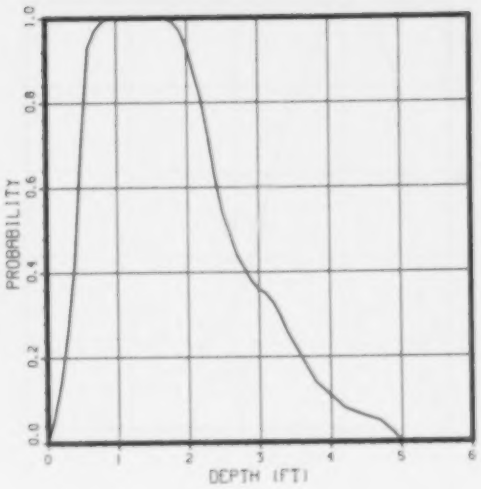



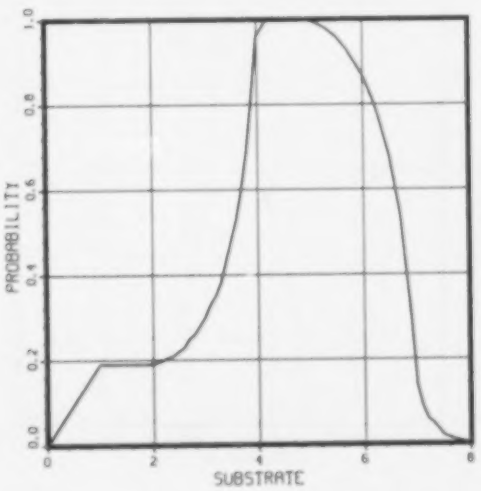



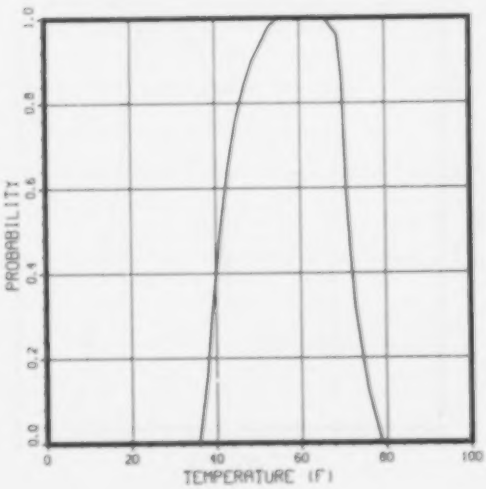
BROWN TROUT

11300 FRY 78/01/24.



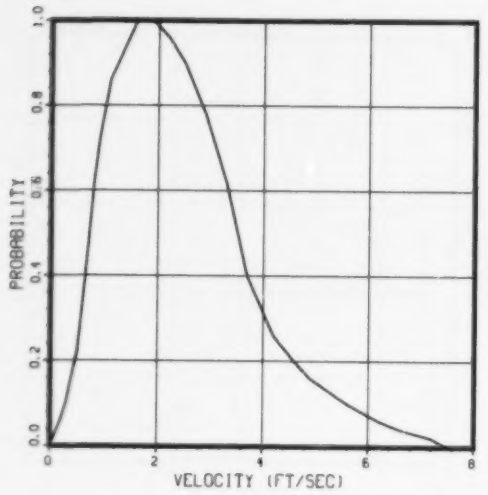



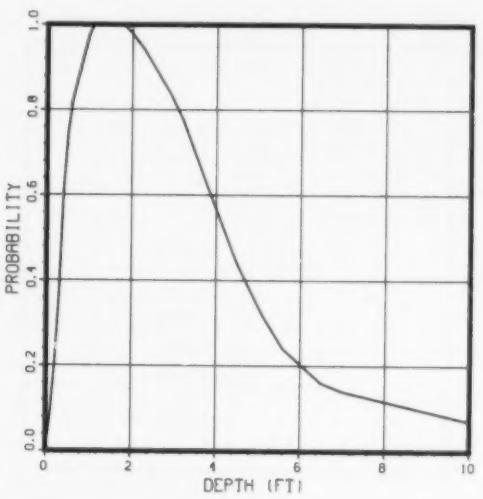



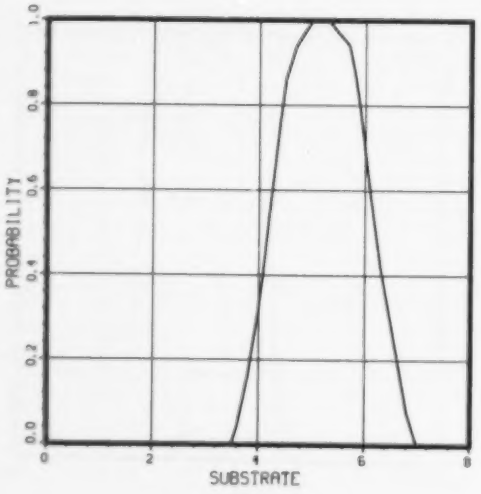



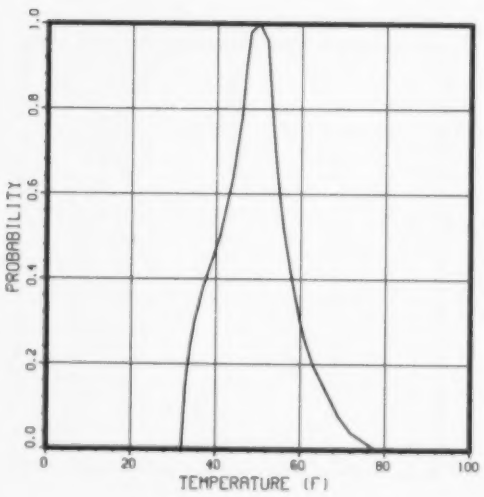
BROWN TROUT (CLEAR WATER, S=.001)

11321 INCUBATION 78/01/24.



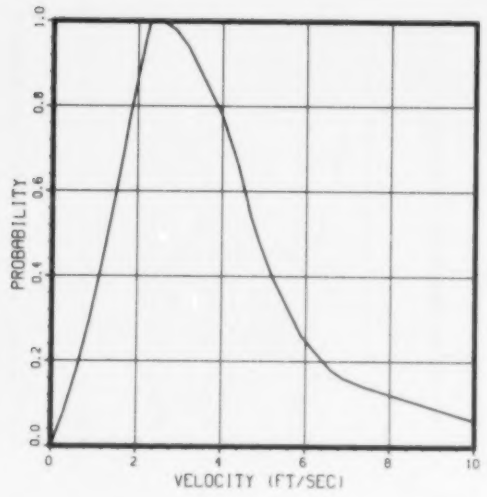



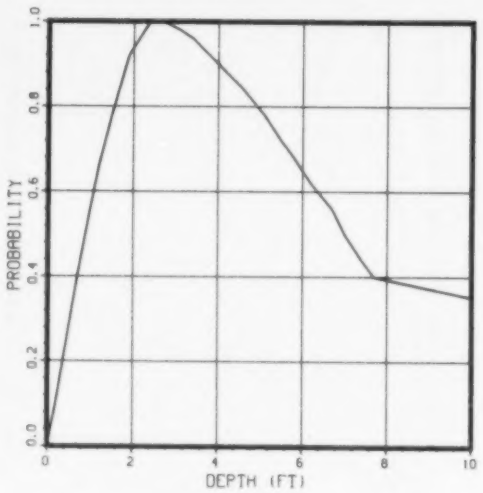



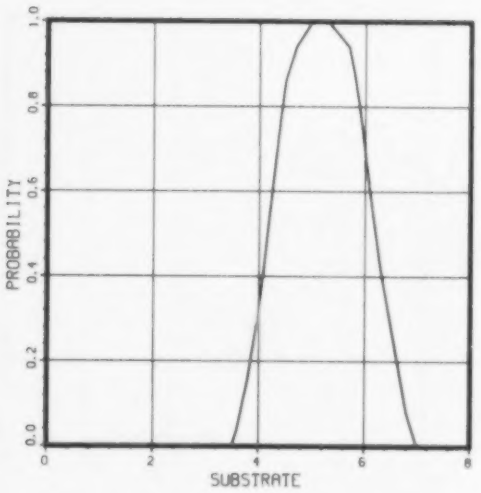



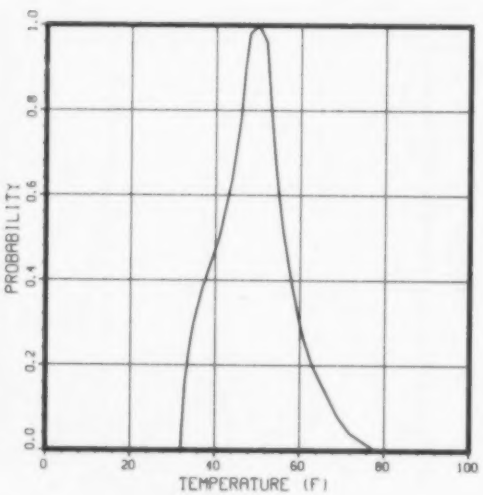
BROWN TROUT (TURBID WATER, S=.001)

11322 INCUBATION 78/01/24.



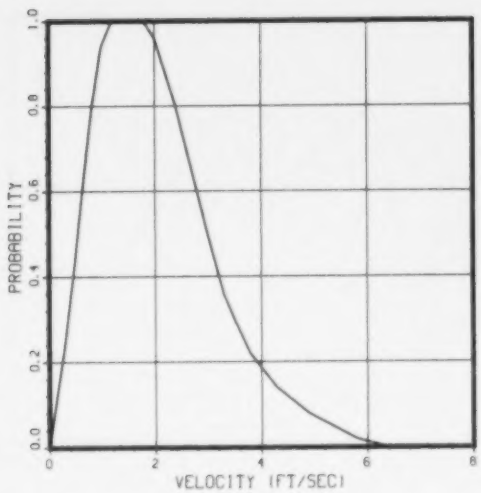



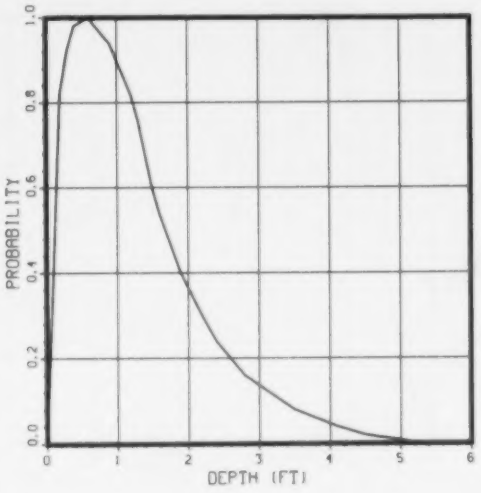



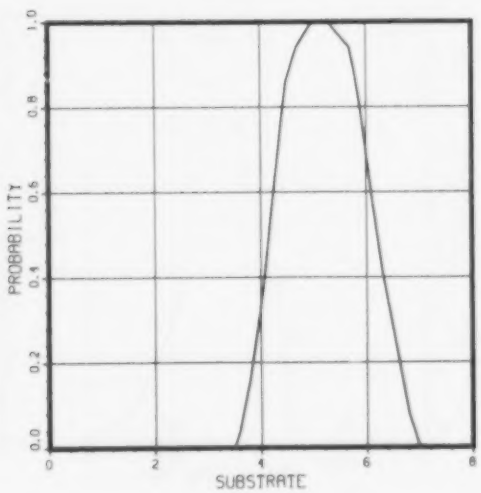



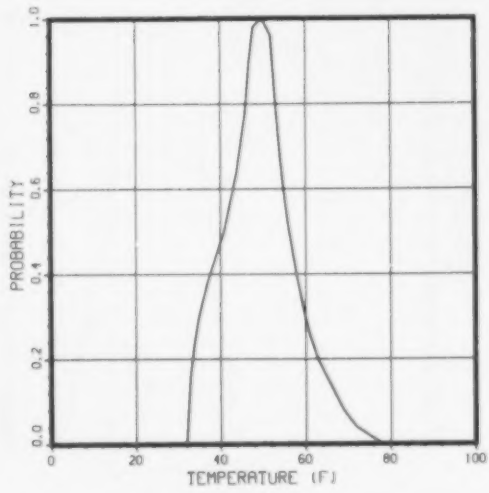
BROWN TROUT (CLEAR WATER, S=.0025)

11323 INCUBATION 78/01/24.



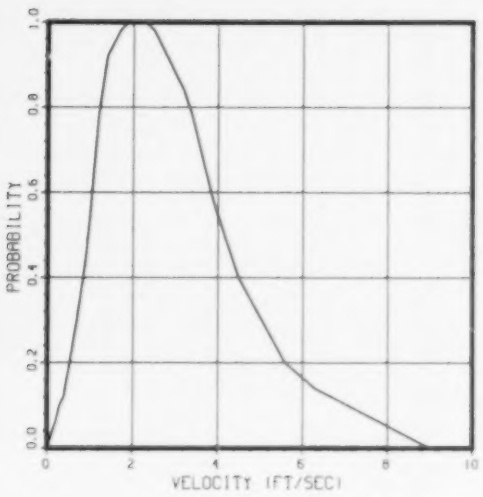



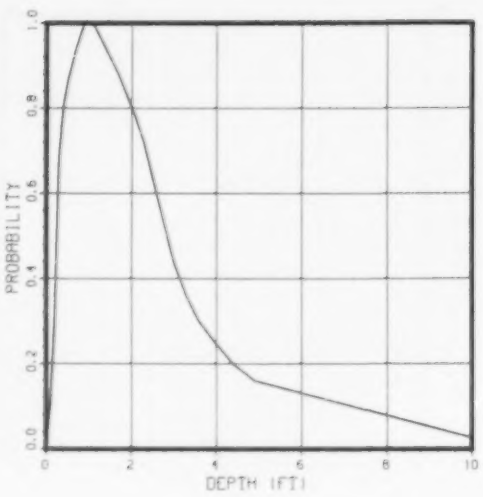



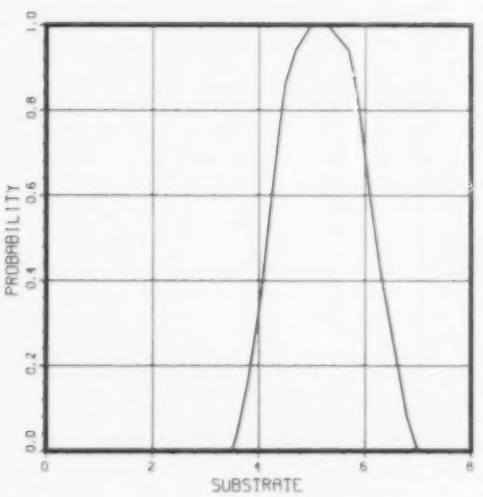



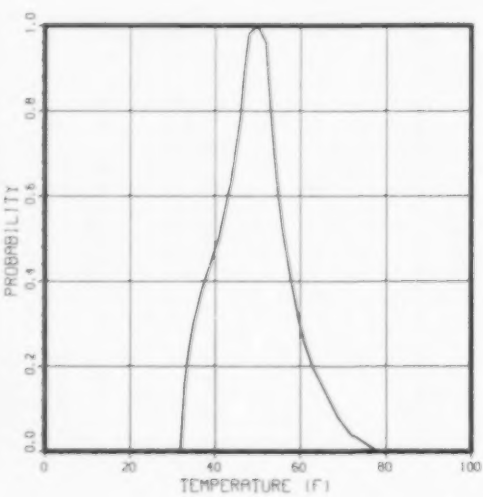
BROWN TROUT (TURBID WATER, S=.0025)

11324 INCUBATION 78/01/24.



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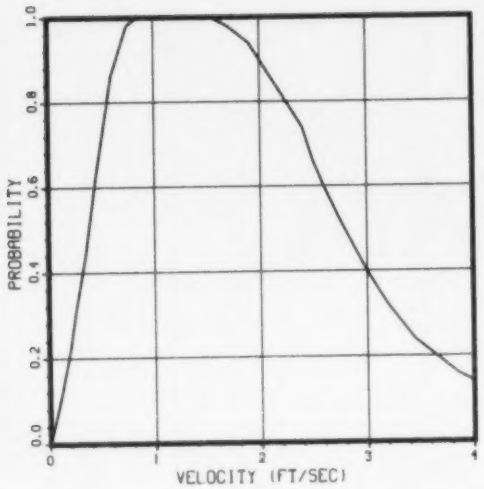
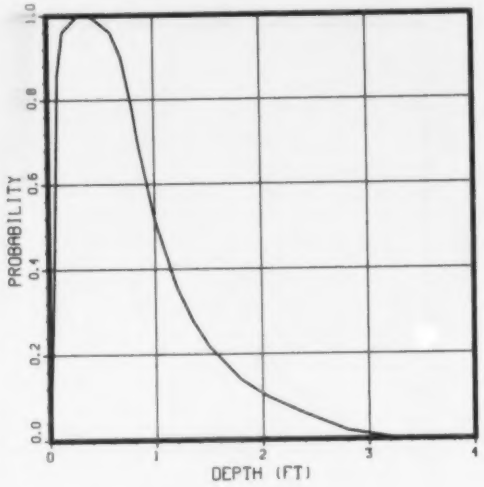
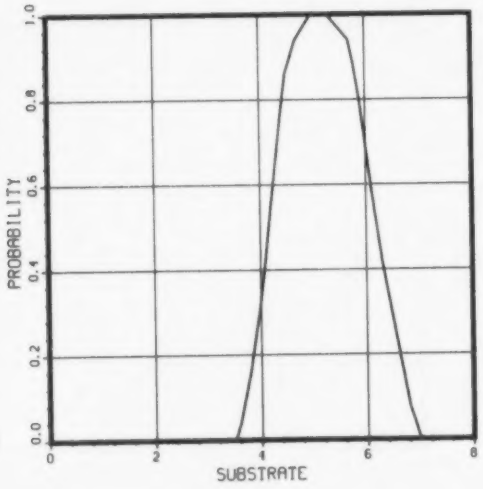
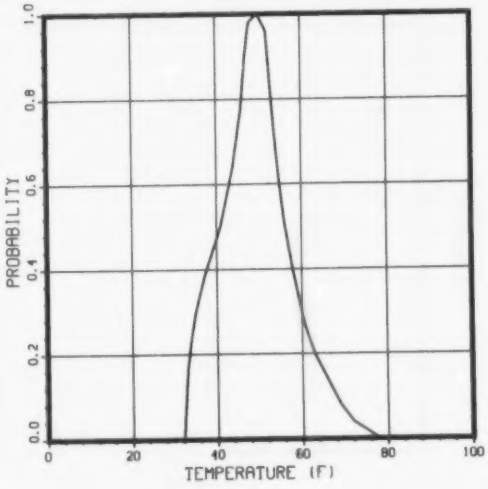
11325 INCUBATION 78/01/24.



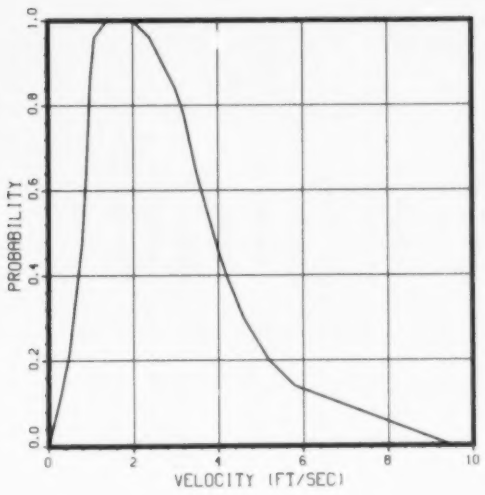



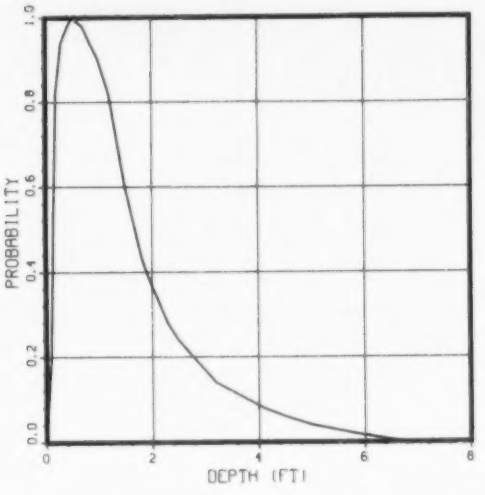



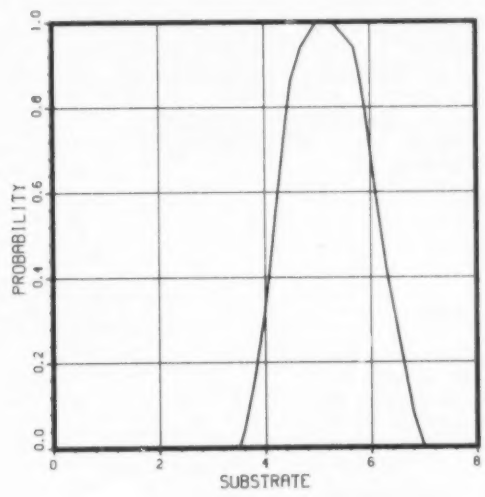



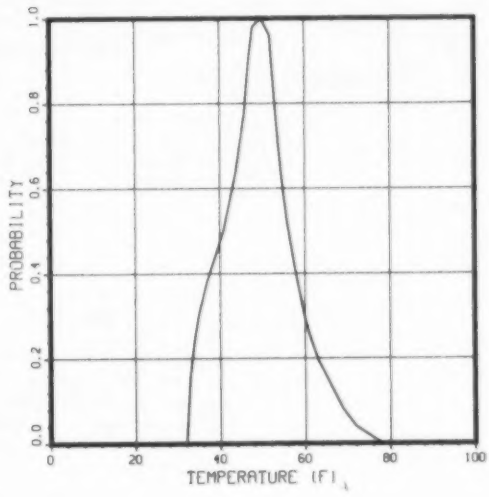
BROWN TROUT (TURBID WATER, S=.004)

11326 INCUBATION 78/01/24.



# BROOK TROUT

## Salvelinus fontinalis

| Catalog No. | 011410 Spawning | | | | 011402 Adult | | | | Juvenile | | | | Fry | | | | Egg Incubation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES: Brook Trout | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature |
| IFG EVALUATION | G | G | G | F | R | R | R | F | | | | | | | | | | | | |
| REFERENCE / ANALYSIS | 22 FA | 22 FA | 20 RO | 12 RO | 12 FA | 12 FA | 12 RO | 2 RO | | | | | | | | | | | | |
| | 29 FA | 29 FA | 22 RO | 22 RO | 35 FA | 35 FA | | 22 RO | | | | | | | | | | | | |
| | | | 29 FA | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| COMMENTS | 1 | 1 | | | 2 | 2 | | | | | | | | | | | | | | |

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

Reference: Refer to listed number in bibliography.

Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

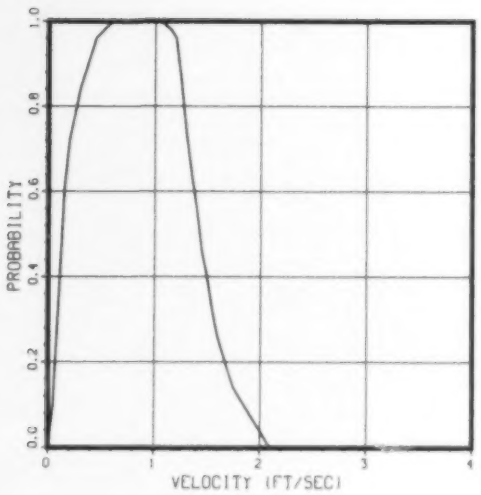
Comments - Brook Trout Curves

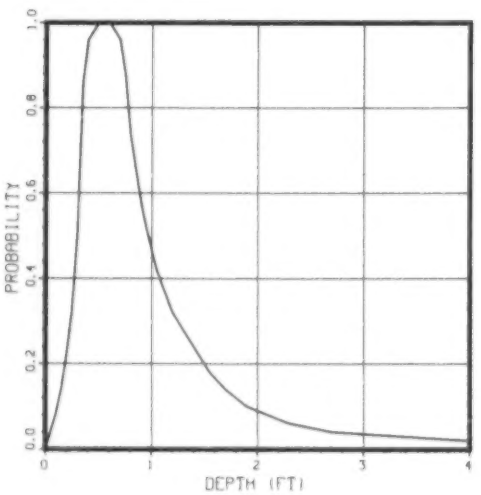
1. Data from Reiser & Wesche (1977) were taken in small streams for 7 to 9" brook trout. Hunter's (1973) data came from a wider range of conditions and was given double weighting in the frequency analysis. These curves represent a composite of large and small spawners and would be skewed to the left for small spawners alone.

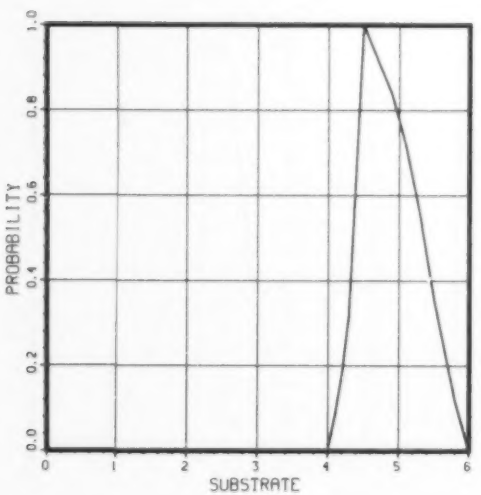
2. The depths and velocities in Stewart's study were measured the year prior to his population sampling. Therefore, there is no way of knowing that the flow conditions measured were those actually inhabited by the fish.

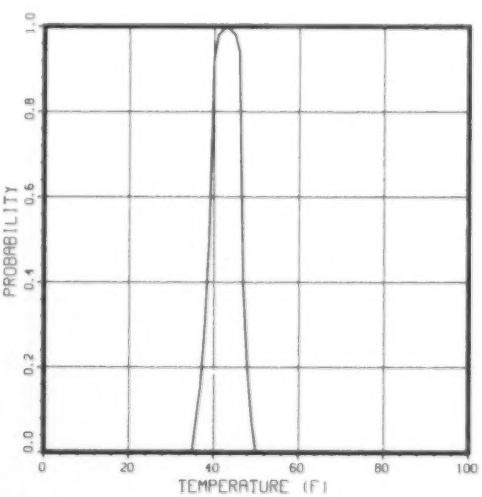
BROOK TROUT

11410 SPAWNING 78/01/24.



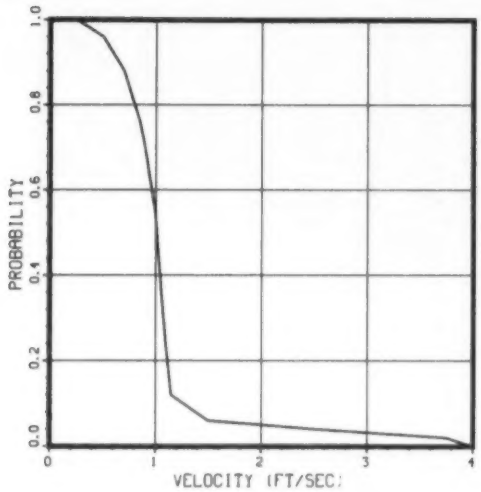



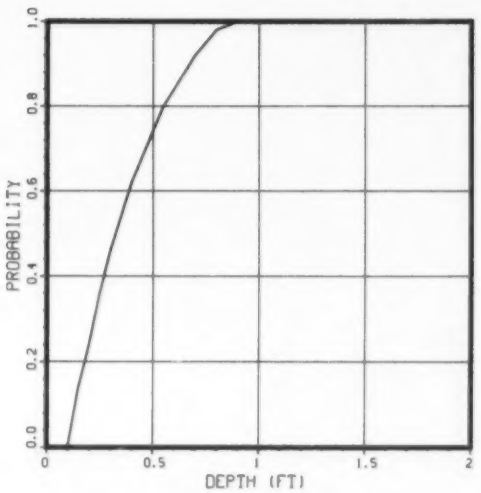



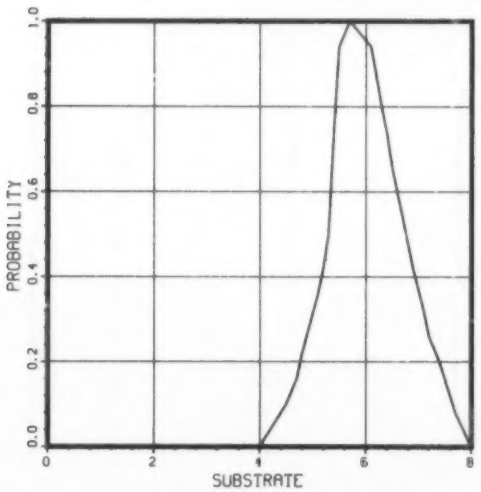



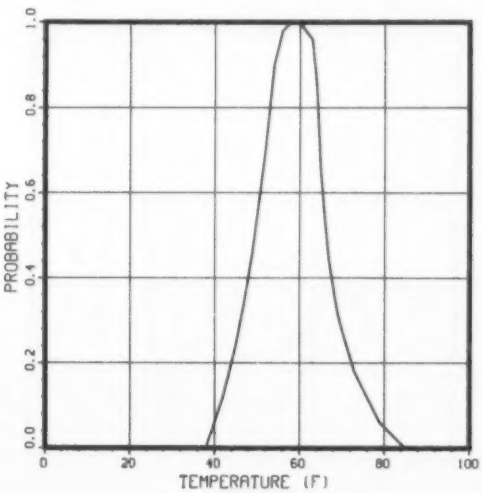
BROOK TROUT

11402 ADULT 78/01/24.



# MOUNTAIN WHITEFISH

## Prosopium williamsoni

| Catalog No. | 12010 Spawning | | | | 12002 Adult | | | | 12001 Juvenile | | | | 12000 Fry | | | | Egg Incubation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES: Mountain Whitefish | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature | Velocity | Depth | Substrate | Temperature |
| IFG EVALUATION | F | F | F | F | G | E | G | F | G | G | E | F | G | G | G | F | | | | |
| REFERENCE | 33 | 6 | 6 | 6 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | | | | |
| ANALYSIS | FA | RO | RO | RO | FA | FA | FA | FA | FA | FA | FA | FA | FA | FA | FA | FA | | | | |
| | 34 | 33 | 33 | | 16 | 16 | 16 | 26 | 16 | 16 | 16 | 26 | 16 | 16 | 16 | 26 | | | | |
| | RO | FA | FA | | FA | FA | FA | PO | FA | FA | FA | PO | FA | FA | FA | PO | | | | |
| | | 34 | 34 | | | 6 | | 31 | | | | 31 | | | | 31 | | | | |
| | | RO | RO | | | RO | | PO | | | | PO | | | | PO | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| COMMENTS | | | | | | 1 | | | | | | | | | | | | | | |

**Key to IFG Evaluation Matrix**

**IFG Evaluation:** E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

**Analysis:** FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

**Reference:** Refer to listed number in bibliography.

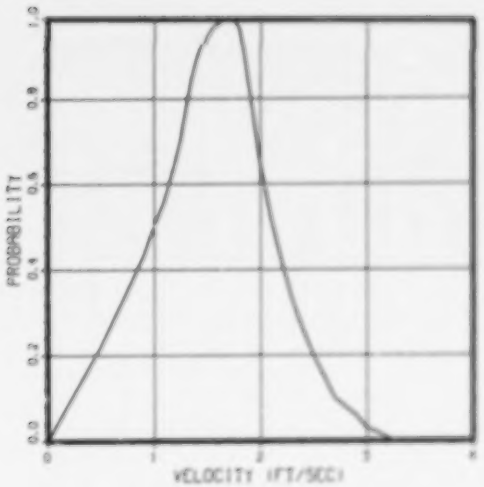
**Comments:** Refer to listed number on comment sheet (following IFG Evaluation Matrix).

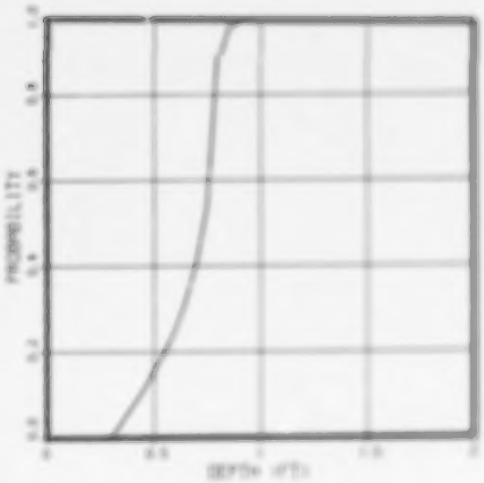
Comments - Mountain Whitefish

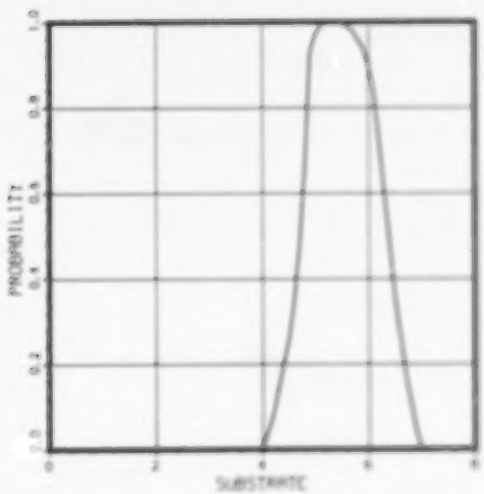
1. Despite the large sample size, the optimum could not be tested beyond 2.5 ft in depth due (probably) to lack of habitat in the greater depth ranges. Optimum line continued by observations from Brown (1952).

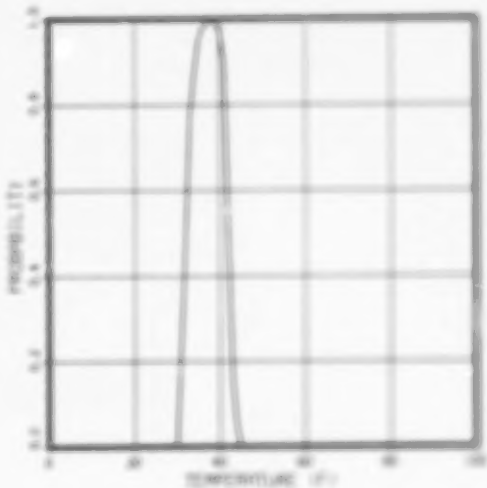
MOUNTAIN WHITEFISH

12010 SPAWNING 78/01/24.



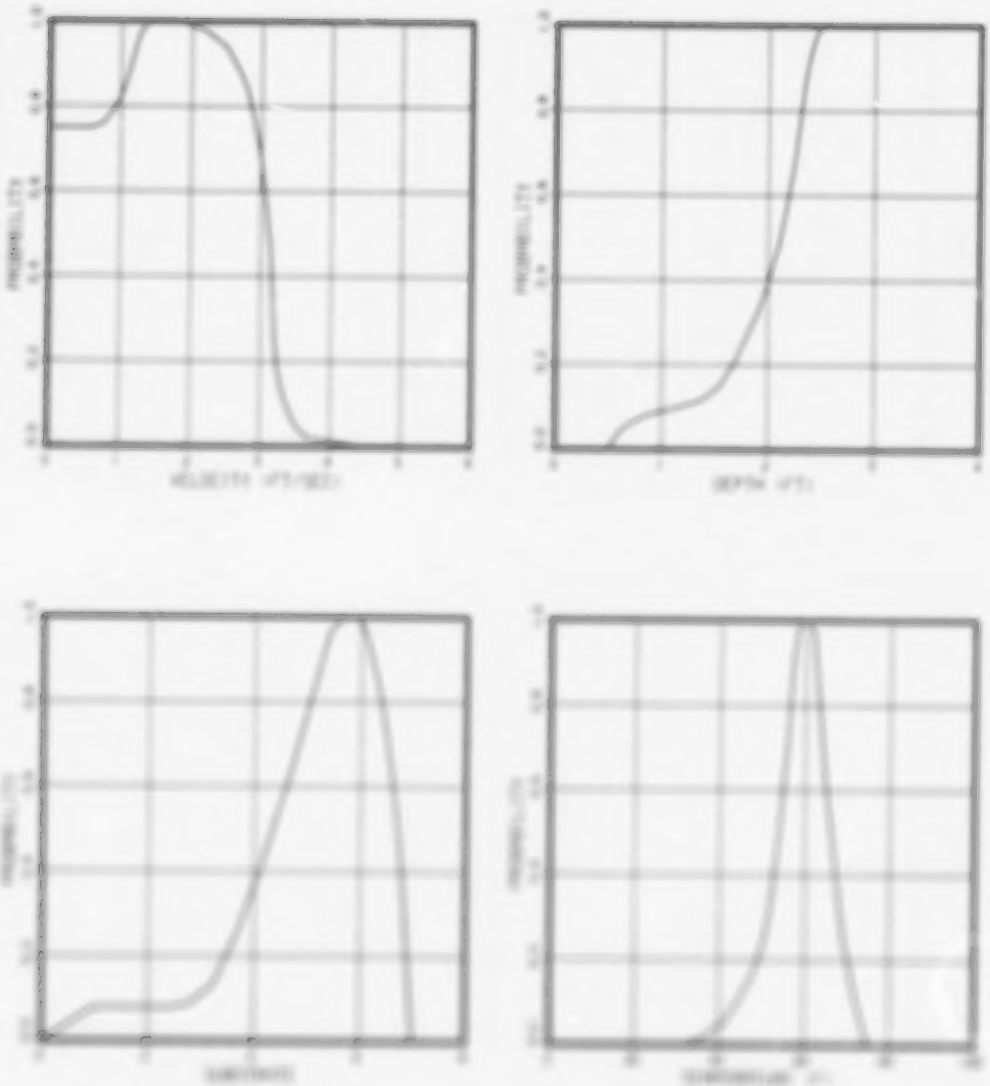



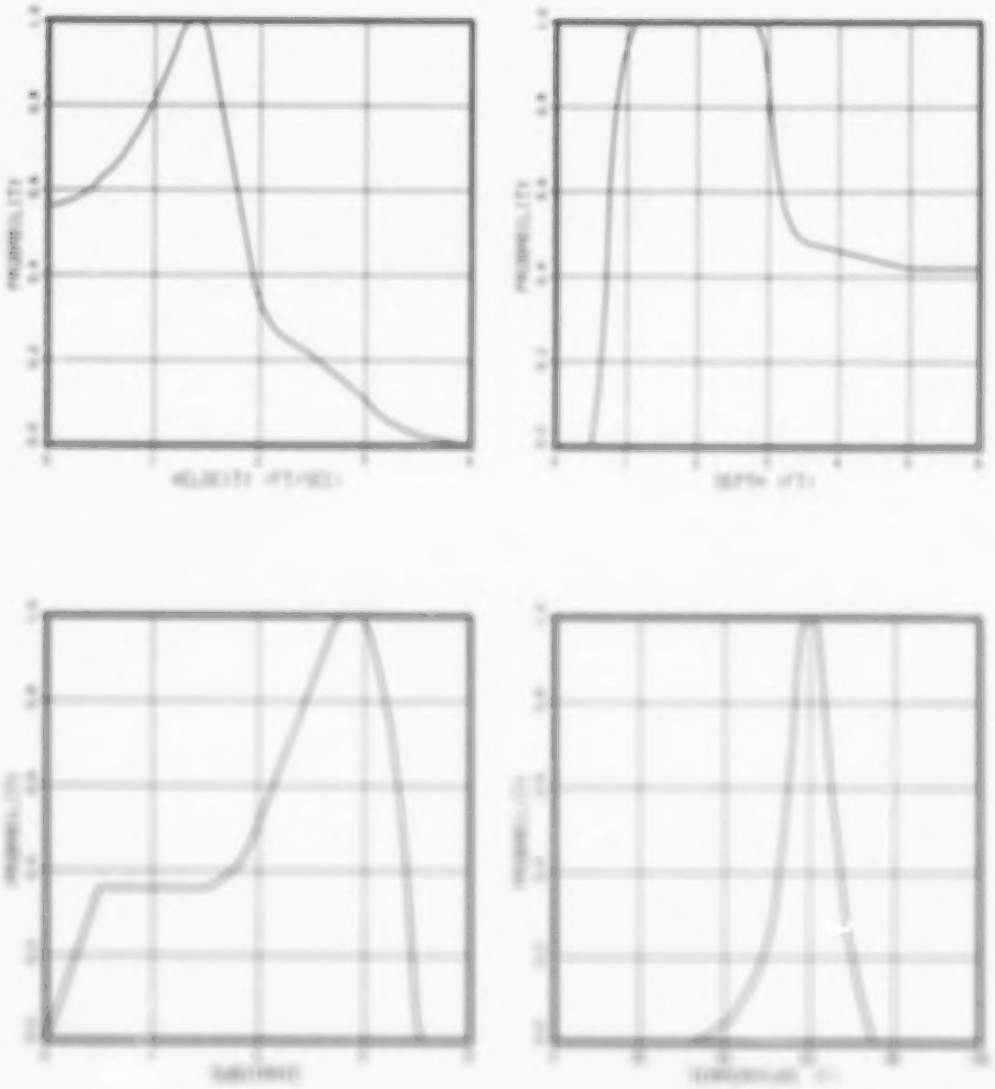
MOUNTAIN WHITEFISH

12002 ADULT 78/01/24.



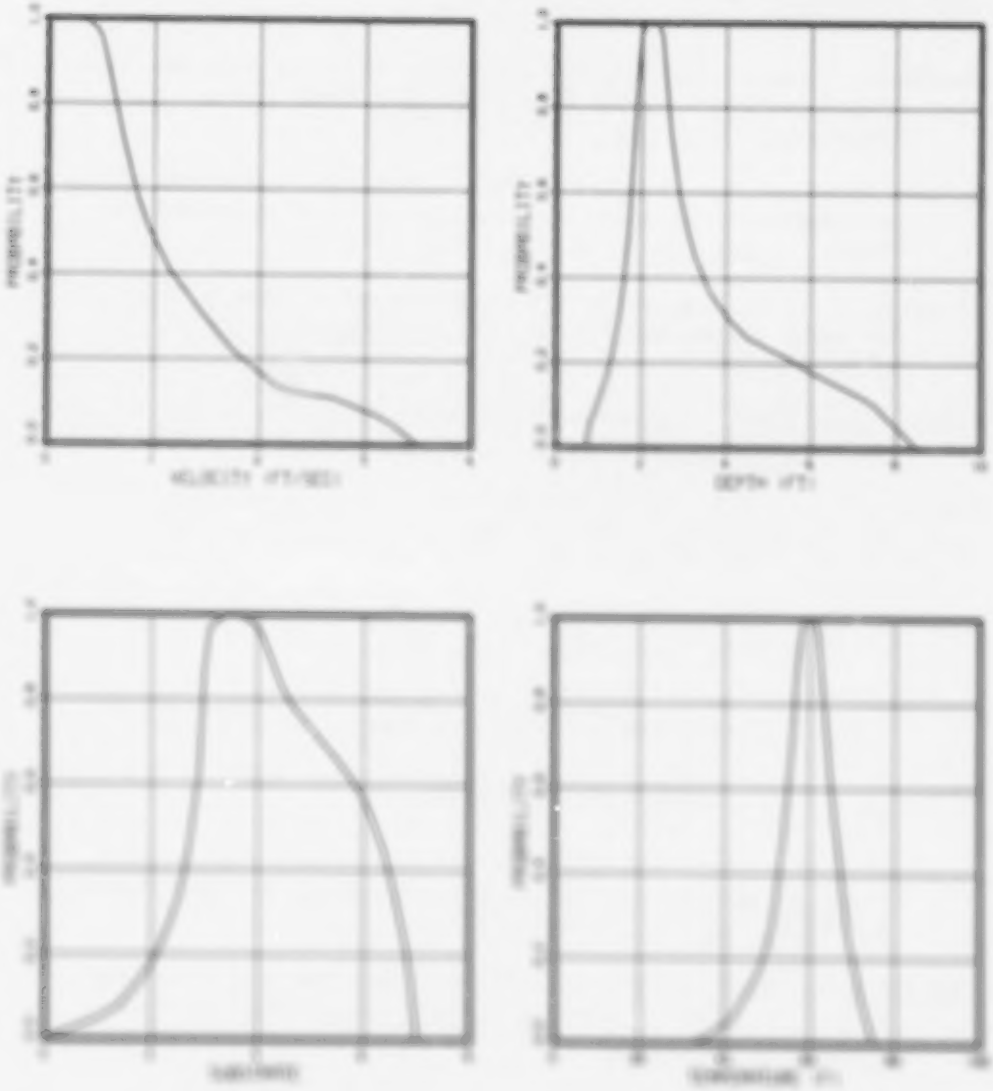
MOUNTAIN WHITEFISH

12001 JUVENILE 78/01/24.



MOUNTAIN WHITEFISH

12000 FRY 78/01/24.



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3. Bovee, Ken D., and Cochnauer, Tim. Development and Evaluation of Weighted Criteria , Probability-of-Use Curves for Instream Flow Assessments; Fisheries. Fort Collins, Colorado, Cooperative Instream Flow Service Group, December 1977, 49 pages. (NTIS Accession Number: PB ; Library of Congress Catalog Card No. - ).

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2. To gather, analyze, and present information that will aid decisionmakers in the identification and resolution of problems associated with major land and water use changes.

3. To provide better ecological information and evaluation for Department of the Interior development programs, such as those relating to energy development.

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The Program consists of the Office of Biological Services in Washington, D.C., which is responsible for overall planning and management; National Teams which provide the Program's central, scientific and technical expertise, and which arrange for contracting of Biological Services studies with States, universities, consulting firms, and others; Regional staff who provide a link to problems at the operating level; and staff at certain Fish and Wildlife Service research facilities who conduct inhouse research studies.